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ACADEMIC FREEDOM IN THE MODERN STATE

THE appearance after an interval of two years of a new review of the activities of the Rockefeller Foundation* would in any event be of considerable interest, and especially as in this survey Mr. Chester Barnard attempts to re-assess the objectives of the Foundation and its position in the world. He is not content merely to describe the reorientation of the Foundation's activities and its new objectives, but also endeavours to relate them to the general needs and problems of our time. This analysis is of the more interest in view of some comments on the position of such voluntary bodies which are made in the seventh report from the Nuffield Foundation†, published almost simultaneously. Together the two reports give an encouraging picture both of the way in which such voluntary bodies are able to foster creative work and also of their indispensability if human society is to remain healthy and flexible in an age when research itself is increasingly dependent on public, or rather State, support.

Mr. Barnard points out that the resources of the Rockefeller Foundation are limited indeed in the face of the myriad wants of mankind, and because of this disparity the Foundation can select for support only those wants which represent critical needs and which provide opportunities for service in fields that are at the very basis of human well-being. In discharge of that heavy responsibility of selecting the most appropriate projects, the trustees and officers of the Foundation are entitled to draw some encouragement from the results which have flowed from some almost trifling grants. Mr. Barnard refers to the way in which the Montreal Neurological Institute, to which the Foundation has already appropriated nearly one and a half million dollars, has arisen from a grant of 2,784 dollars made twenty-five years ago to Dr. W. Penfield for a fellowship in neurosurgical research at McGill University.

Mr. Barnard uses this grant to illustrate the potency of the comparatively small grants—at least when measured against the resources of the State—which independent and voluntary organizations can make for research. Nevertheless, he emphasizes that the principle of adequacy is the correct yardstick to apply in any decision regarding the magnitude of a grant, and his discussion of this point vividly recalls some remarks of Sir Henry Tizard in his Messel Memorial Lecture. This illustration is even more significant, however, in its demonstration of the value of the voluntary organization with its freedom to experiment in fields where it would be difficult for the State to commit its own resources. The Rockefeller Foundation, as Mr. Barnard sees it, must work, irrespective of the magnitude of the project which is to be undertaken or of the size of the grant which is to finance it, with small groups, such as university departments, laboratory teams and individuals, who

* The Rockefeller Foundation: a Review for 1950 and 1951. By Chester I. Barnard. Pp. 126. (New York: Rockefeller Foundation, 1952.)

† Nuffield Foundation. Report for the Year ending 31 March 1952. Pp. 162. (London: Nuffield Foundation. 1952.)

are both technically competent and intellectually free.

From this point of view Mr. Barnard shows concern at the increase of restraints on individual and group freedoms imposed in the interests of national security. The code of morals prevalent in Western society, in his view, rests on the twin pillars of the freedom and the responsibility of the individual. Recognizing the necessity for security and the difficulties of attaining it, he discusses what adjustment can be made that will preserve the life of the mind without endangering national security.

Mr. Barnard thinks that the sense of responsibility to institutional and public interest within the academic fraternity in the United States is not, on the whole, as mature as is desirable. With some qualification, that is possibly true of academic circles in Great Britain also, and it will be remembered that Prof. A. V. Hill made a similar comment in his presidential address to the British Association. Nevertheless, free discussion in the academic world is of increasing importance when so many activities in other fields are largely and necessarily subject to formal co-ordination and to central direction.

The Rockefeller Foundation, Mr. Barnard points out, endorses the view that only the free mind is capable of really productive intellectual work, either in research or in teaching, and that the man or woman who has an ideological axe to grind is conspicuously less successful as a contributor of knowledge than one who is free of such a restriction. The two personal criteria by which the Foundation judges eligibility for grants and fellowships are technical competence and integrity as a scholar. The first requisite for intellectual integrity is an open mind; once a man becomes a partisan in his search, and accepts the dictation of external authority as to the interpretation of the phenomena he observes, he ceases to be a scholar.

That still needs saying, and Mr. Barnard's further contention that those who sacrifice their freedom to a party line thereby disqualify themselves for research, and automatically exclude themselves from the immunities granted by society to the scholar in exchange for his dedication of himself to the search for truth, points the way towards a solution of the problem of freedom and loyalty and responsibility. The view taken by Mr. Barnard is, in fact, thoroughly realistic. Strongly as he argues that freedom to inquire, to observe, to theorize, to exchange ideas and experiences and to criticize, is essential to fundamental research and for creative work of any kind, he recognizes too that in some areas of research, where national security is involved, the traditional liberty of the scholar is subject to restriction in the interests of the nation and society. It cannot be granted as an inalienable right, and the scientific man who wishes to work in such areas must accept the restriction as an unavoidable evil. If he feels that he cannot fulfil his responsibility in research unless he can communicate his findings freely with other scholars and share their discoveries, a man of science should withdraw and work in another field where such secrecy considerations are not over-riding. He can claim no right to set his own judgment as to the necessity of free communication above the judgment of those who may be no less concerned with scientific advance but who are responsible also for maintaining national security. Moreover, to withdraw, as Prof. Hill very clearly indicated, is probably the surest way of emphasizing to the nation and to society the high cost of secrecy measures, and the way in which such measures impede both scientific discovery and technical development.

In this review, Mr. Barnard sounds a warning that has been given before in the Rockefeller Foundation reports; but while it is clear that the Foundation would be seriously concerned at any considerable extension of secrecy areas, the purpose of the present warning may equally be to give notice of the Foundation's concern with intellectual integrity, and its desire to foster a keener sense of public responsibility on the part of the scientific men and other scholars. The issue of academic freedom is also raised by the Nuffield Foundation in its seventh report, but from a rather different point of view. Although the fears expressed in its previous report of a sudden setback to the development of university work in Britain through a contraction of government spending have not been realized, the Foundation is still somewhat exercised as to the possible effects the increasing dependence of the universities upon public money may have on the traditional independence of academic work and the freedom of universities to manage their own affairs.

Some three-quarters of the total income of the universities of Britain will presently be derived from government sources, and while for the moment the universities will only have to face such restrictions on their activities as may be imposed by rising costs, the Nuffield Foundation is somewhat concerned at a passage in the Fifth Report of the Select Committee on Estimates for the Session 1951–52. That report, which subjected to careful analysis the grant-in-aid of universities and colleges from the point of view of public accountability, provided a striking indication of the effectiveness of the University Grants Committee system. The Select Committee was satisfied that the arrangement successfully harmonized academic freedom with proper control over the expenditure of public funds, and at the same time urged the desirability of securing the maximum contribution from private benefaction and local support.

It is on this question of further revenue from private gifts and endowments that the Nuffield Foundation is critical. The Select Committee noted that there was evidence of the same antipathy on the part of universities towards ear-marking by private benefactors as towards ear-marking by the Exchequer. Private benefactions, indeed, are apt to be even more restrictive than State ear-marked grants, and 54 per cent of total endowments are given for particular purposes. The Estimates Committee made no comment on this point; but the Nuffield Foundation takes up strongly the plea that private benefactions should not be tied by the donors to the

creation of some particular facilities or the promotion of special projects.

Universities naturally prefer to be left unfettered in deciding the best use for such private donations, so that they can experiment with new developments or test out novel ideas; and the Foundation is fully mindful of the needs and circumstances of universities as centres of teaching at the highest level and of most of the research which advances knowledge. In previous reports, the Foundation has stressed the importance to-day of the comparatively much smaller but alternative resources which private funds can offer in support of activities so speculative as research. In the present report, the Foundation makes a spirited defence of its practice of making grants to universities for particular rather than for general purposes.

In doing so, the Nuffield Foundation could have drawn upon the experience of the Rockefeller Foundation as well as on its own. Both bodies, in seeking to use their endowments to foster those advances in knowledge from which human welfare stands ultimately to gain, have been concerned primarily with the exceptional men upon whom those advances depend. Both have made their grants more for special individuals than for special projects, and the Nuffield Foundation can claim with reason that it has been privileged on occasion, by enlarging the resources available at a university, without imposing restrictive conditions, to enlarge also the freedom both of the exceptional individual and of his institution. The object of any Nuffield Foundation grant is simply to give the individual able worker the means for carrying forward experiment and knowledge in the way which, because it suits him, is likely best to serve his subject.

The example cited by the Foundation in this report to demonstrate the decisive value of private benefactions for a specific purpose is the personal grant from Lord Nuffield in 1942 and grants from the Nuffield Provincial Hospitals Trust in 1943, which prevented the dispersion of Sir Howard Florey's team of research workers on penicillin. The instance cited by Mr. Barnard of the fellowship for neurological research equally establishes the value of the specific grant; and on the evidence of these two reports alone there can be no doubt as to the contribution to scientific advance which the voluntary association can make by means of its grants and endowments for specific purposes.

Implicit in both these reports is the belief in wise and responsible selection of individuals and projects. No objection has been raised to the acceptance of ear-marked grants or endowments from bodies of the standing of the Nuffield Foundation or the Rockefeller Foundation, with their established tradition of wise selection and public responsibility. It can equally be agreed that the fellowship schemes like those of Imperial Chemical Industries, Ltd., where full freedom of choice is allowed within whole scientific disciplines, are also a means for encouraging the emergence of the exceptional investigator. It would be unwise, however, to assume that every private benefactor will possess either the same tolerance or keen sense of public responsibility. Save where the repute and standing of the benefactor in these respects are beyond dispute, the universities are wise to prefer the uncommitted grant or endowment. Bodies like the Nuffield Foundation and the Rockefeller Foundation have an essential part to play in encouraging the development of backward or neglected fields. Great Britain could ill spare the effort which the Nuffield Foundation, for example, proposes to make during the next five years to encourage fundamental research in the United Kingdom in the biological and sociological fields, and to utilize special opportunities in other fields of medicine and science, as well as in old people's welfare and in the finance of biological and other research in the Commonwealth, particularly in the utilization of local resources.

But the Nuffield Foundation is well qualified to discuss the opportunities which exist or can be created for work of high standard in such fields. Its choice, in the ultimate resort, is made on the quality of the individual and is guided by lively contacts with academic thought and practice. The real issue for us to-day is to secure the continuance of such independent bodies, and provide the conditions by which such voluntary effort can continue to maintain the growing points and opportunities for experiment in society to which the State itself—directly or indirectly—can with difficulty, if at all, commit itself. Perhaps the most encouraging feature of the present report from the Nuffield Foundation is the indication it affords of the way the Foundation finds it possible to work, formally and informally, in co-operation not only with the universities but also with the major departments of State and the official research organizations, and to bring to the common task the flexibility, initiative and independence which mark the voluntary body.

FREEZING AND DRYING

Freezing and Drying

Report of a Symposium held in June 1951. Pp. 206. (London: Institute of Biology, 1952.) 15*s*.

THIS report contains all the papers read at a symposium at the Institute of Biology which was held in London during June 1951. In addition to the papers, the whole of the discussion which followed them has been included. The complete compendium is a most valuable contribution to this rapidly expanding subject.

The principle of freeze-drying is, of course, dependent upon the fact that frozen water has a significant vapour pressure, and even at − 20° C. this is equal to about 0·9441 mm. of mercury. Consequently, in a vacuum of a lower pressure than this, the frozen water will pass directly into vapour (that is, it will sublime) and can be removed from the system. Progressive removal of the water vapour so formed will eventually cause the drying of the tissue. Biological fluids and tissues kept at these low temperatures remain virtually inactive. Autolytic reactions do not take place, growth of micro-organisms is prevented and proteins are not denatured. Moreover, most enzyme activity of tissues and fluids

frozen-dried in this way is maintained. The advantages of freeze-drying were, of course, made use of during the Second World War, when the production of large quantities of dried blood-plasma and penicillin were made possible by its use. A glance at the list of papers read at the symposium and recorded in this volume demonstrates the range of activities to which this technique is now applied.

First, there is a series of four papers on what can best be described as large-scale freeze-drying—that is, treatment of antibiotics and foodstuffs—by this method, and also discussions on methods of freeze-drying. A second section deals with effects of freeze-drying on the viability of cells and tissues. Here we have papers on mammalian skin, tumour tissues, spermatozoa, red blood cells and endocrine tissue.

A third section records the effects of freeze-drying on bacteria and viruses, and a fourth discusses the problems of tissue fixation by freezing and drying and its significance in histochemical and cytological studies. This latter problem was, in fact, first investigated by Altmann as long ago as 1890, but was neglected until it was more fully investigated and improved in the early 1930's by Isadore Gersh in the course of his studies for the degree of Ph.D. at the University of Chicago; Dr. Gersh himself read the opening paper in this section.

It can be seen that there are few biological activities —commercial, bacteriological, cytological, etc.— which are not affected by the development and further application of this new technique. This volume should therefore have a wide and ready sale.

As a record of the first symposium held by the newly formed Institute of Biology, the book augurs well for the future of the Institute's activities.

Geoffrey H. Bourne

HORMONES IN PLANTS AND INVERTEBRATES

The Action of Hormones in Plants and Invertebrates

Edited by Kenneth V. Thimann. (Reprinted, with additions and supplementary bibliographies, from 'The Hormones', Vol. 1.) Pp. viii+228. (New York: Academic Press, Inc., 1952.) 5.80 dollars.

THIS volume consists of four essays on the hormones of plants, insects and crustaceans, gathered together under one cover in the hope that their proximity might lead to the same sort of unification as has occurred in mammalian endocrinology. One is left with the impression that the realization of unity has been somewhat less than the anticipation. Although each of the essays possesses considerable intrinsic value to workers in the particular field discussed, there seems to be relatively little carry-over between the various groups. In fact, one is led to wonder whether the study of hormones has as yet been so significant a unifying force in biology as the editor believes. Aside from the universal occurrence of hormonal mechanisms of correlation and control in complicated organisms, one can think of no major generalizations to make. If other basic similarities do, in fact, exist, they need to be pointed out, for they are well hidden.

The four essays are "Plant Growth Hormones" and "Other Plant Hormones" by Prof. Kenneth V. Thimann of Harvard University, "Hormones in Insects" by Berta Scharrer of the University of Colorado, and "Hormones in Crustaceans" by Prof. Frank A. Brown, jun., of Northwestern University. They have been reprinted from Vol. 1 of "The Hormones" (1949), together with some additions to the text and supplementary bibliographies to bring them up to date as of late 1951. It is hoped that such supplementation will make complete revision unnecessary for some years to come.

Prof. Thimann's article on plant growth hormones is a skilful condensation and modernization of the kind of material originally presented in Went and Thimann's "Phytohormones". The result is a brief coherent survey of the state of our knowledge of the chemistry and physiology of the auxins up to five years ago. Because of the extremely rapid advances which are now being made in this field, parts of the auxin story are somewhat out of date, and the inclusion of the recent bibliography does not quite remedy the situation.

The chapter on "Other Plant Hormones" is especially welcome, since it summarizes much material not before integrated. One may find here authoritative discussions of the wound hormone, flower-forming hormones, vitamins which act as plant hormones, leaf growth-factors, calines and the hormones of fungi. Since relatively little important work has been done in these fields in the years since the article was originally written, it is as complete and up-to-date a review as one could hope to find.

The comparatively young field of invertebrate endocrinology has very recently produced a spate of interesting discoveries on hormonal regulatory effects in insects and crustaceans. Most of these hormones have been shown to exist by purely physiological and surgical means, and in only one instance, the formation of eye pigments in *Drosophila* and *Ephestia*, has the chemical nature of the hormone been definitely ascertained. Nevertheless, these studies hold great promise for an eventual rationalization of the complex problems of growth and morphogenesis, especially in the insects.

Dr. Scharrer discusses insect hormones under the following headings: (*a*) hormones controlling postembryonic development, (*b*) sex hormones, (*c*) hormones affecting pigmentation, and (*d*) "gene hormones", that is, hormones directly involved in the expression of a particular gene. Although distinct differences are shown to exist among various orders of the insects, it seems clear that in all groups there are hormones controlling larval growth, pupation and moulting. It also seems clear that an 'anti-differentiation factor' (the juvenile hormone of Wigglesworth) is present. In this respect, one can see a broad analogy with plants, in which there appears to be a growth versus sexual differentiation control by the interplay of auxin and florigen. The corpora allata, the centres of synthesis of the juvenility factor, may thus be regarded as analogous with the stem tip, in which the major share of auxin synthesis occurs; and the neuroglandular intercerebralis-cardiacum complex, which produces the growth and differentiation hormone, with the leaves which produce florigen. It would be interesting to know whether the production of the growth and development hormone in insects is as sensitive to environmental control as is the synthesis of florigen in plants.

In the Crustacea, discussed by Prof. Brown, no single hormone has yet been obtained in a pure state,

but many are known to exist. As in the insects, they control colour-change, moulting and growth, sexual processes, and certain aspects of growth, development and metabolism. Some of these hormones have been hypothesized almost exclusively on the basis of observation, as in the effects of parasitic castration on secondary sexual characteristics. With others, especially hormones involving colour changes, a sound experimental basis for their existence has been laid. The account of the hormonal control of chromatophores by the sinus gland and central nervous organs is especially exciting.

The study of hormones in plants and invertebrates, which began less than thirty years ago, has already wrought a revolution in our understanding of the physiology of these types of organisms, and the increasing tempo of research augurs well for its future. This volume is a valuable chronicle of progress in a vigorously growing field, and it is hoped that it may aid in achieving the unity in biology to which Prof. Thimann dedicates it.

ARTHUR W. GALSTON

THE FULMAR POPULATION

The Fulmar

By James Fisher. (New Naturalist Series.) Pp. xv+496+52 plates. (London and Glasgow: Wm. Collins, Sons and Co., Ltd., 1952.) 35*s.* net.

THE nucleus for the present work was the British Trust for Ornithology Inquiry into "The Breeding, Distribution, History and Population of the Fulmar (*Fulmarus glacialis*) in the British Isles", conducted by the author and George Waterston (*J. Animal Ecol.*, **10**, 204; 1941). In the published paper the spread of the fulmar from one colony in 1874 to 269 colonies in 1939 was considered by the authors to be "due to a biological change which is not understood". As a plankton-eating arctic species the fulmar should have been retreating northwards with the shrinking of the ice-cap and the amelioration of the climate of the northern hemisphere—but, in fact, it was moving south at a great rate. They wrote: "Correlations may exist between the spread of the fulmar and its food, but it will be a Herculean task to discover them".

A simple solution was, however, discovered by Marchant and myself on our visit of nine days at Rockall in June 1948, when we became convinced that the fulmar's increase was related to the availability of the tons of fish offal which are thrown into the sea each hour of each day all the year round by the great fleets of deep-sea trawlers of the maritime nations of Western Europe. We saw up to five thousand fulmars at one moment devouring this offal, which was hosed over the side of the trawler after the gutting of each trawl-load of about a ton of fish every four hours day and night. As it is now known that the larger petrels are capable of long fasts and of flying great distances there is no reason why most of these fulmars at Rockall (or at any other trawling bank) should not be breeding birds from the nearest colonies between two and four hundred miles away. At least fifty thousand fulmars were present on the Rockall Bank during June 1948 (they could not have all been non-breeders), which is $2\frac{1}{2}$ per cent of Fisher's estimated world population of one million pairs of Atlantic fulmars. Once it had tasted offal in this form the individual fulmar would be likely to attend trawlers regularly and even become quite dependent on this (at present) unfailing and abundant food supply. Hence the rapid colonization by nesting sites along the Iceland–British Isles seaboard within a few hundred miles of the trawling grounds. Making use of this hypothesis, the author has investigated the northern fisheries as far back as the height of the whaling period of the seventeenth century. Whale-flensing provided an abundant, though only seasonal, supply of offal for the scavenging fulmar. His analysis shows a significant correlation: a slight increase in the number of fulmar colonies during two hundred years of whaling, a rapid increase with sixty years of deep-sea trawling; the increases taking place near the sites of these fisheries.

A short review cannot do justice to the excellence of this large monograph. Fisher shows how much of the breeding biology is yet unknown; the incubation period has not been accurately measured; and a theory of intermittent breeding is discredited. Field ornithologists especially will welcome his lucid presentation of the history of the distribution and increase of this remarkable petrel, gathered as it has been from the reading of more than 2,400 references. Disappointingly, none of these is listed in the monograph; but we are promised the bibliography later.

R. M. LOCKLEY

NEW LIGHT ON ALCHEMY

The Alchemists

Founders of Modern Chemistry. By Dr. F. Sherwood Taylor. Pp. x+246. (London: William Heinemann, Ltd., 1951.) 12*s.* 6*d.* net.

DR. F. SHERWOOD TAYLOR'S book appeared very appositely just at the time of the recent exhibition of alchemical books at the Science Museum, South Kensington. It is apposite in another way also, for the modern trend in history pays much more attention than ever before to the growth of ideas, and it is from this point of view that Dr. Sherwood Taylor surveys his subject. The literature of alchemy is formidable, not only for sheer bulk but also for its complexity and often deliberate obscurity; many of its students have sooner or later become discouraged by vain attempts to thread their way through the labyrinth, and have indeed doubted whether, if it could be threaded, there would be anything worth discovering at the centre. One may, of course, investigate the alchemical *corpus* solely in order to assess the matter-of-fact chemical knowledge contained in it; but even this is not easy on account of the enigmatic nomenclature so generally favoured by the alchemists. Genuine practical chemistry is, however, only one facet of the alchemical crystal: the sparkle comes mainly from the numerous facets of doctrine. What Dr. Sherwood Taylor has set out to do, and what, in fact, he has succeeded in doing very well, is to examine alchemical doctrine to see if any coherence and continuity can be detected in it. He has the advantage of being a chemist versed not only in chemistry but also in theology, philosophy, and mysticism, and has thus been able to follow clues imperceptible to one less well equipped.

What emerges from this careful and original study is that, in spite of its paraphernalia of alembics, cucurbits, pelicans, and furnaces, alchemy was essen-

tially a religious philosophy aimed at the unification of all Nature in a single scheme under Divine guidance: there is a causal chain of descent from God to matter. As the author points out, this is compatible with Christian theology, but it is equally compatible with Muslim theology; allowing for Muslim disbelief in the Trinity and in the divinity of Christ, it is possible to trace quite clearly the continuity of alchemical philosophy from the Brethren of Purity to Thomas Vaughan.

Dr. Sherwood Taylor makes the further point that, owing to its religious basis, alchemy would have no truck with black magic. This is an interesting suggestion, and it is to be hoped that the author will expand it in a further book or paper; the dividing line between alchemists and magicians was surely not always very well defined.

While I have directed attention to what seem to me to be the important contributions to alchemical studies made in the book, it should be added that the main story is a beautifully written and well illustrated account of alchemy from the earliest times: quite the best account yet given in such compass. It will interest all who are curious about man's interpretations of Nature and its relations to the Deity, and, if it be the history of an error, the error was one extremely tenacious of life. It is, indeed, not dead even in this twentieth century: I remember seeing a practising alchemist of the old school, Al-Hajj Abdul-Muhyi Arab (once Mufti of the Shah Jehan Mosque at Woking), absorbedly bending over a heated ladle which was always going to, but never did, deliver a golden stream of transmuted lead.

E. J. Holmyard

PHYSICAL CONCEPTS, NEW AND OLD

The Scientific Adventure

Essays in the History and Philosophy of Science. By Prof. Herbert Dingle. Pp. ix+372. (London: Sir Isaac Pitman and Sons, Ltd., 1952.) 30*s*. net.

THE author of this collection of essays and lectures presides over one of the most interesting and progressive academic 'schools' in Great Britain—that of the history and philosophy of science in the University of London. Thus it is appropriate that he should divide his book into two sections, one historical and one philosophical. As he is at pains to point out, however, he is more specifically in his element when concerned with the latter than with the former. Nevertheless, of the past he has much of consequence to say.

Although composed for a wide variety of occasions, there is a certain thread of continuity running through these pages, a strand of astronomy, astrophysics and cosmology deftly intertwined with their associated epistemological correlates. Amidst much of importance, there should be little difficulty in recognizing that Chapters 1, 9 and 19 (the last) are outstanding in their respective fields. To these, therefore, in general, this review will be restricted. But before getting to grips, one notices how true to type they are. The first, being frankly historical, leaves us to draw—as indeed we must—the conclusions based upon several centuries of scientific endeavour. The other two are quite different in that they propound questions possibly unanswerable. This seems perfectly legitimate, and in full accord with the traditional duty of a philosopher, especially since many an ordinary person (if such exists) would scarcely dream that such problems were stuff for thought at all, let alone disciplined inquiry. It is the merit of these papers that, through reading them, attention is inevitably directed to the presence of several formidable philosophical hurdles confronting the individual and society. There may be little inclination to try to jump them, but to know that they are there is salutary.

Chapter 1 describes what are in effect two life-lines, one that of the logical development of scientific knowledge, the other the actual. Naturally, at certain points they intersect. Broadly, however, the factual course is strewn with minor deviations which lead nowhere, whereas the chart of formal progress is dead straight. Prof. Dingle points the moral clearly. The logical *Lebenslauf* is the lot of the student, if only for the reason that to wander aside into history might touch off some sparks of interest, and thus endanger his effective working hours. As things are, it is only rarely that he has any chance of appreciating how major discoveries and inventions came about; he is constrained largely to pool them in order to get some kind of tidy conspectus. Experience, however, goes far to condemn this tendency, because it is crystal-clear that the capacity for original work of the highest order is more often than not found in those who have deliberately studied the past and pondered over its message.

Turning now to Chapter 9, this deals with "the philosophical viewpoint of the scientist". The emphasis is upon two anomalies, to which the author has devoted a great deal of thought. One is the subject–object relation. The other concerns time. The solution offered is to regard the subject "as inevitably stationed at the present", whereas the object is to recede into the past. Following upon this, reason is seen not to be objective "in the act of thought", whereas experience is found to be placed in time.

Towards the end of this chapter comes the link which seems to join it without constraint to Chapter 19. This is the problem of ethics. We are faced with the Kantian co-equals, 'practical reason' and 'pure reason'; and, sure enough, back we are driven to the categorical imperative. This the author fails to find coercive, and, philosophically speaking, the majority of mankind will agree with him. But, once again, nothing can be done about it.

From here, the reader may well survey the last contribution as from a point of vantage. Its subject is "science and religion". Even to anyone a little wearied of such a theme, it must appear as exceedingly well conceived. Perhaps the reason for this is because Prof. Dingle refuses to get bogged down in the *minutiæ* of what will always, on this side Jordan, be essentially subjective and personal experiences. Yet—and here is the strength of this particular presentation—they are none the less real for that.

Time was, and perhaps to some degree still is, when philosophy was the accredited handmaid of theology, and proud to share a palace with the queen of the sciences. This ancillary relationship has since become somewhat difficult. It is not wholly a question of 'abdication'; events have made it less easy for 'the Crown' to keep clear of, and to sit above, the stresses and strains of contemporary life. But these are matters only discernible maybe upon another plane of discourse, namely, that on which we shall know, even as we are known.

F. I. G. Rawlins

Quantum Mechanics of Particles and Wave Fields

By Prof. Arthur March. Pp. x+292. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 44*s*. net.

PROF. A. MARCH'S book is a very welcome addition to the literature of modern developments in the quantum theory of particles and wave fields. The changes in centres of interest in this subject are well indicated by the fact that one-half of this book is devoted to the subject of relativistic wave equations, and to the quantization of wave fields. The earlier chapters give a good introduction to the earlier developments in quantum theory, including, of course, Schrödinger's wave equation and the principles of matrix mechanics. The later chapters are peculiarly interesting and suggestive, as they deal with the central problems of quantum electrodynamics.

There is a curious passage on p. 179 which seems, at least on the surface, to be at variance with the usual interpretation of Dirac's wave equation. Prof. March writes: "It is important to realize the physical significance of the wave equation (248) [that is, Dirac's wave equation]. It has been emphasized already that this equation no longer permits an interpretation in the sense of non-relativistic quantum mechanics. As long as it is not quantized, it has no relation whatever with particles, but controls the behaviour of a field that is not purely symbolic but actually represents a physical reality. This is clear from the fact that, according to (249), (251), and (253), the field possesses charge, energy, and momentum, and thus it can be measured relative to these observables. It is only a question, then, as to whether wave fields corresponding to the assumed equation really exist, a question that must be answered in the affirmative". This interpretation is so unusual that Prof. March might well have referred to the fact that most writers, including Dirac himself, regard the relativistic wave equation as referring to the behaviour of an individual particle.

G. TEMPLE

The Lipids

Their Chemistry and Biochemistry. By Prof. Harry J. Deuel, Jr. Vol. 1: Chemistry. Pp. xxiv+982. (New York and London; Interscience Publishers, Inc., 1951.) 18.50 dollars.

THE term lipid has been interpreted in its fullest sense, and the author discusses not only the simple lipids (fats and waxes, 405 pages) but also the compound lipids (phosphatides and cerebrosides, 102 pages) and the derived lipids (carotenoids, 160 pages, and vitamins A, D, E and K, 194 pages). The author does not claim to be an authority in all these fields, though it is suggested, in the preface, that this will make the book less involved and therefore more understandable to non-specialist readers.

For so large a book, the number of mistakes is small, though some have been noted. For example, the formulæ on p. 168 (1 : 2-benzylidene glycerol), 428 (choline chloride) and 602 (azafrinone) are in error. It is stated (p. 88) that linolenic and elæostearic acids are the only octadecatrienoic acids known; but octadec-6 : 9 : 12-trienoic acid, reported to occur in *Œnothera biennis* seed oil, is a member of this series. The statement (p. 242) concerning the low iodine value of linolenic acid seems doubtful, while the section on atmospheric oxidation of unsaturated fatty acids and their natural derivatives is somewhat inadequate, making no reference to the important new developments reported in this field by many workers during the past decade.

Despite these errors and omissions, the general style of the book is pleasing, and I have read it with profit and enjoyment. References are copious, and the indexes (121 pages) appear to be very complete. The book is most useful to the reader in those parts of the field in which he is not a specialist.

F. D. GUNSTONE

A Basic Course in the Theory and Practice of Quantitative Chemical Analysis

By Prof. George L. Clark, Prof. Leonard K. Nash and Prof. Robert B. Fischer. Pp. xxi+448. (Philadelphia and London: W. B. Saunders Co., 1949.) 21*s*.

QUANTITATIVE analysis is one of the fundamental branches of the science of chemistry, and the proper instruction of the beginner in the broad essential aspects of the subject is invaluable to him in whichever field he may eventually specialize. This book, written by three authors with considerable experience in the teaching of analytical chemistry, forms an excellent introductory course for students.

Part 1 deals with gravimetric analysis, and Part 2 with volumetric analysis, the method of presentation in each case being a logical combination of theory and practice. Three representative determinations have been treated with unusual care and completeness in order to lead the inexperienced student to the proper critical approach to the subject, the later methods being dealt with in somewhat less detail. Part 3 describes briefly the modern instrumental methods of analysis. Many of the chapters are followed by review questions and problems which serve to test the reader's grasp of the subject-matter. Part 4 consists of ten short appendixes, including those on essential mathematics for quantitative analysis, standardization of weights and statistical treatment of experimental data.

The book is well written and well produced, but, from the British reader's point of view, the use of such terms as "precipitimetry" and "compleximetry" is to be deplored.

A Text-Book of Practical Organic Chemistry, including Qualitative Organic Analysis

By Dr. Arthur I. Vogel. Second edition. Pp. xxiii+1033. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1951.) 50*s*. net.

THE issue of a second edition of this laboratory manual only three years after the publication of the first edition (see *Nature*, **161**, 995; 1948) is evidence of the popularity which it has deservedly achieved. The new edition is, in fact, little more than a reprint. For the most part the pagination corresponds with that of the first edition; but it is stated that the opportunity has been taken to correct various minor errors and to incorporate some suggestions made to the author. The appendix is enlarged by the inclusion of examples of new preparative methods in common use. These are the formation of some acetylenic compounds by liquid ammonia reactions; the use of N-bromosuccinimide; the Huang-Minlon modification of the Wolff–Kishner reaction; reductions with lithium aluminium hydride; cyanoethylation; and the use of organo lithium compounds. These are welcome additions. There is no doubt that this book has established itself as a medium of instruction in practical organic chemistry.

J. W. COOK

METEORITES AND COSMIC RAYS

By Dr. S. F. SINGER

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THE extensive measurements of Paneth and his collaborators[1] of the uranium, thorium and helium content of iron meteorites have established a method for determining the time elapsed since their solidification. The widely varying 'ages' obtained by this method have led Bauer[2] and also Huntley[3] to suggest that cosmic rays may provide an additional source of helium and therefore affect these determinations. Certain of Bauer's more detailed conclusions have been criticized[4]; but it seems very likely that the ages quoted[1] represent upper limits. (Underlying all of this work is the assumption, for which there is experimental support[5], that the diffusion of helium, and therefore its loss, is negligible at ordinary temperatures due to the structure of iron meteorites.)

The problem of helium production by cosmic rays has therefore been re-examined[6]. (1) By taking into account the important contributions of cosmic-ray secondaries and other factors, one obtains a lower limit for the rate of helium production which is more than an order of magnitude greater than Bauer's value. One also comes to a conclusion different from Bauer's about its variation with depth in the meteorite. These calculations can be checked by related experiments; a calibration may also be obtained from self-consistent age measurements on a single meteorite. (2) A method is developed here for separating experimentally the helium contribution by cosmic rays and by radioactivity; it is based on the fact that cosmic rays are able to produce substantial amounts of helium-3 either directly or through tritium, whereas the radiogenic helium consists entirely of helium-4.

The results of such studies on the total amount of radiogenic and cosmic-ray helium can then be applied to give a correction to the age determinations of meteorites and to other cosmological problems[6].

Production of Helium

A number of processes are known by which the cosmic radiation can produce helium in meteorites (strictly speaking, 'meteoroids'). The most important contribution comes from the excitation of iron nuclei by fast cosmic-ray particles, and the subsequent evaporation of helium-4 and helium-3 nuclei, and of tritium nuclei which decay into stable helium-3. Other processes of lesser importance contribute to the helium production, namely: (1) primary helium nuclei stopping in the meteorite; (2) helium fragments from the break-up of heavy primary nuclei; and (3) heavy unstable nuclei ejected in cosmic-ray induced disintegrations ('stars') which break up into α-particles[7].

These events differ in some respects from those occurring in the atmosphere. The effect of the higher atomic weight of the meteorite will be to change the characteristics of the 'average' star[8], while due to the much higher density of the meteorite most π-mesons (themselves produced in nuclear encounters) will interact before decaying into non-interacting μ-mesons, and thus carry the helium production process to greater depths. (On the other hand, the effects of low-energy neutrons which produce tritium in the atmosphere[9] can be neglected here.)

The rate of production of helium-3 and helium-4 in iron has been calculated in two essentially different ways; they lead to concordant results. One method uses a cosmic-ray flux figure extrapolated from measurements on the primary radiation, empirical interaction cross-sections, and results of evaporation theory[10]. The other more empirical approach combines certain features of evaporation theory with a statistical study based on about 12,000 cosmic-ray stars, obtained by the University of Bristol group in high-altitude exposures.

Not only the primary radiation, but also lower-energy secondaries (protons, neutrons and π-mesons) are effective in producing stars. For this reason the amount of helium produced reaches a rather flat maximum some distance from the surface of the meteorite, and falls off rapidly with distance only after a depth of about 25 cm. The results given here apply for the case of an infinitely large meteorite having a nearly plane boundary. (In practice, this would correspond to a 'pre-atmospheric' diameter rather greater than one metre.) For meteorites of small size or odd shape, these results can be used, together with a suitable numerical calculation to take proper account of the solid-angle factor.

The final numerical value for the rate of helium production (by a flux of cosmic rays corresponding to the present-day value in the vicinity of the earth's orbit) in the region 2–15 cm. from the surface of an iron meteorite is $(5 \pm 1{\cdot}5) \times 10^{-14}$ c.c. of helium at N.T.P. per gm. of meteorite material per year. Of this amount ~ 30 per cent is calculated to end up in the form of helium-3.

The errors given are estimated ones and based on the present state of knowledge of cosmic-ray processes. In any event, it is thought unlikely for the rate of production to be appreciably lower, since all known cosmic-ray effects are believed to be taken into account. It should be pointed out also that the fraction of helium in the form of helium-3 decreases slowly with decreasing mean energy of the star, and hence with increasing depth in the meteorite.

These estimated errors are not likely to be reduced appreciably by further refinement of the calculations. A more promising approach, particularly with regard to the ratio of helium-3 to helium-4, comes from the experimental side, where one can attempt to simulate in the laboratory the exposure of meteorites to cosmic rays. As a first step in this direction, Dr. W. Barkas has kindly exposed a stainless steel target in the Berkeley 340-MeV. proton synchrocyclotron; this sample is now being analysed at the University of Durham. It is hoped to continue this approach by exposing a suitable sample in a bevatron, which produces protons in the cosmic-ray energy region. Independently, an experimental check on certain features of the evaporation theory and its application to an iron nucleus can be obtained by analysing by means of a magnetic field and nuclear emulsions the evaporation products of stars produced by cyclotron protons[11]. Following a different line of attack, nuclear *C*-2 and *G*-5 emulsions loaded with thin iron filaments have been obtained through the courtesy of Prof. G. P. S. Occhialini (Brussels) and Mr. C. Waller (Ilford, Ltd.). These have been exposed to the cosmic radiation at mountain altitudes.

Age Correction

Making the proper correction to the meteorite age requires the subtraction of cosmic-ray helium from the helium sample extracted from the meteorite. (A typical sample would amount to $\sim 10^{-6}$ c.c. helium per gm. of meteorite.) It is necessary first to measure the amount of helium-3 in the sample. After subtracting the helium-3 plus the proper amount of cosmic-ray helium-4 (calculated from the ratio above), one is left presumably only with radiogenic helium-4. The age can then be calculated by conventional methods[1].

The helium isotope ratio in the sample can probably be determined with modern mass-spectrometric equipment[12]. For very small samples, however, a radiochemical procedure based on Coon's method[13] may also be of value. Helium-3 is known to have an extremely large absorption cross-section (about 5,000 barns) for thermal neutrons. The (n,p) reaction occurring produces tritium, which is β-unstable and is transformed back into helium-3 with a half-life of 12 years. Exposure of a helium sample containing only 10^{-8} c.c. of helium-3 in a nuclear pile for a few days would give sufficient tritium to produce a measurable activity. It is proposed to determine the helium-3 content of the meteorite sample by comparing this activity with those from calibrated samples (enriched with helium-3) exposed under identical conditions. (Even smaller amounts of helium-3 could be detected by the use of special triton counters[14].)

In view of the fact that a unique age should result from a series of corrected age determinations obtained from different parts of the same meteorite, it may be possible to obtain a consistency check of the numerical result given in this article for the cosmic-ray helium isotope ratio and a calibration of the variation of this isotope ratio with depth in the meteorite.

Meteorites as Integrating Cosmic-Ray Meters

Some additional applications of the cosmic-ray helium method to problems of cosmological interest are pointed out here. These remarks must be viewed with some reserve, because of the many uncertainties about the physical history of meteorites. (For example, the helium gas may have diffused through the meteorite and have escaped if the latter was exposed to high temperatures.) Essentially one wants to provide an experimental test for the following assumptions: (1) the meteorite has been exposed directly to the primary cosmic rays from the time of solidification to the time of chemical analysis (that is, over the whole time interval during which radiogenic helium was allowed to accumulate); (2) this primary cosmic-ray intensity experienced by the meteorite corresponds to the flux in the vicinity of the earth; and (3) the average intensity over the life-time of the meteorite corresponds to the present-day intensity.

(1) By making use of the fact that cosmic rays produce helium in meteorites, one can develop the concept of considering a meteorite as an integrating cosmic-ray meter which gives one the time and space integral of the cosmic-ray flux it encounters over its path and life-time. From the corrected age of the meteorite and the amount of cosmic-ray helium, an empirical rate of helium production by cosmic rays can be determined and compared with the rate calculated on the basis of the assumptions just stated. It may then be possible to gain information about the cosmic-ray intensity in prehistoric times; or the intensity in the region where the meteorite spent the major part of its existence. A low value of cosmic-ray intensity obtained in this way may also be interpreted by assuming that the meteorite did not become exposed to cosmic rays until some time after its solidification, or that it landed on the earth during prehistoric times.

(2) By virtue of the fact that (in very large meteorites) the production of helium by cosmic rays is a 'surface effect' as opposed to the volume effect of radioactivity, one may hope to learn more about the physical processes undergone by the meteorite in its creation and in its travel through space. In particular, by determining its loss of mass in its traversal of the earth's atmosphere, it may be possible to establish an experimental test for the theory[15] of astroballistic heat transfer of a meteorite.

Full details of the present work will appear in *Geochimica et Cosmochimica Acta*. Experimental work on the possibility that helium-3 exists in meteorites is now in progress.

I want to express my thanks to Prof. F. A. Paneth for his interest in this work and for many stimulating discussions, also to U. Camerini, D. H. Perkins and S. Sørensen for valuable comments.

[Aug. 15.

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Dr. S. F. Singer has kindly shown me the preceding paper. It may interest readers that in a recent article[1] containing various experimental results—obtained partly in collaboration with the Clarendon Laboratory in Oxford—figures are given for the helium-3 content of five iron meteorites. They are in very good agreement with Dr. Singer's theoretical deductions, as can be seen from the accompanying table.

Name of meteorite	Helium content in 10^{-6} c.c./gm.	Helium-3/helium-4 (%)
Mount Ayliff	36·8	31·5
Carbo	22·0	28·6
Toluca (Durham)	18·9	29·7
Bethany Amalia (Krantz)	3·4	27·8
Bethany (Harvard)	0·36	17·8

For a discussion of these results in connexion with the question of the age of meteorites, the article referred to above in *Geochimica et Cosmochimica Acta* should be consulted.

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ADVANCES IN THERMODYNAMICS

THE first of the laws of thermodynamics discovered was the second, by Carnot in 1824, when he described the cycle known after him and stated 'Carnot's theorem' that the work done in any reversible cycle operating between two temperatures is proportional to the heat supplied at the higher temperature and to the difference of temperatures. This was put into symbolic form by another engineer, Clapeyron, in 1834. Let a quantity of heat q fall through a temperature difference $\delta\theta$ in a reversible cycle and let the work w be done in the cycle, then :

$$w = Cq\,\delta\theta,$$

where C is a function of the higher temperature θ only. The work is $\Delta V \mathrm{d}p$, where ΔV is the volume change at the higher temperature and $\mathrm{d}p$ is the difference of pressures at the higher and lower temperatures ; hence :

$$\mathrm{d}p/\mathrm{d}\theta = Cq/\Delta V. \qquad (1)$$

Both Carnot and Clapeyron adopted the prevailing 'caloric' theory of heat, according to which heat is a material fluid (q equals a constant), and explained the production of work by the 'fall' of caloric through a temperature difference, just as work is obtained from a weight falling between two levels in a gravitational field. 'Energetics' later postulated that every form of energy is a product of two factors, quantity (for example, caloric for Carnot) and intensity (for example, temperature).

The first law of thermodynamics followed about 1849 with the work of Joule, and required that the heat absorbed in the cycle is not indestructible (as Carnot himself had suspected) but part appears as work. William Thomson (later Lord Kelvin) had shown that the original Clapeyron equation (1) gives correctly the effect of pressure on the melting point of ice, and that it could give an 'absolute' definition of temperature. We could say now that if heat, like work, is a form of energy, $\mathrm{d}p\Delta V$ and q have the same dimensions, and hence C in (1) must be the reciprocal of a linear function of temperature, $a + b\theta$; and by assigning suitable values to a and b, an absolute temperature scale, including the zero and the size of the degree, can be obtained. This was done by Thomson in 1850, after he had shown that Clapeyron's equation is still true when some heat disappears. In fact, in (1) only the heat taken in is concerned. In 1850 Thomson and Clausius, independently, stated the second law in its modern form ; but Thomson did more. In 1855 he noticed that (1) can be written in the form :

$$\mathrm{d}w = q.\mathrm{d}T/T, \text{ or } (\mathrm{d}w/\mathrm{d}T) = q/T, \qquad (2)$$

and since :

$$q = \Delta E + w, \qquad (3)$$

where ΔE is the energy increase of the system in the finite change at the higher temperature in the cycle and w is the work done :

$$\mathrm{d}w/\mathrm{d}T = (\Delta E + w)/T. \qquad (4)$$

In these equations, T is the absolute temperature reckoned from zero, in the way suggested by Thomson. Equation 4, which combines both laws of thermodynamics, has received various names, a favourite being the 'Gibbs–Helmholtz equation'. It was never stated or used by Gibbs, and was published by Helmholtz only in 1882. Nernst used it in the form :

$$A - U = T(\mathrm{d}A/\mathrm{d}T), \qquad (5)$$

where $A = w$, $-U = \Delta E$.

In 1879, Thomson introduced the name 'motivity' for the part of the energy of a system available for conversion into work. The motivity at constant temperature was renamed 'free energy' by Helmholtz in 1882, and he gave it the symbol F. Hence :

$$w_T = -\Delta F, \qquad (6)$$

and from (4) :

$$\mathrm{d}\Delta F/\mathrm{d}T = (\Delta F - \Delta E)/T. \qquad (7)$$

Thomson showed that his equation 4 applies to various kinds of work, and that it embodies a general law. He also stated that in all actual (irreversible) processes there is a diminution of free energy, which he called a "dissipation of energy".

In 1876, Massieu used the free energy F and another function of state :

$$G = F + pV, \qquad (8)$$

such that in isothermal changes at constant pressure, $-\Delta G = -\Delta F - p\Delta V$ is the work done minus the external work (not, as beginners are apt to think, the work done at constant pressure). These functions were much used by Gibbs in 1876, who wrote $F = \psi$, $G = \zeta$, without giving names to either. It is shown above that the name 'Helmholtz free energy' for F is a misnomer.

A useful subsidiary function, the chemical potential μ, first used by Maxwell in 1874 but extensively applied by Gibbs, may be defined as :

$$\mu = \mathrm{d}F/\mathrm{d}m, \qquad (9)$$

where $\mathrm{d}m$ is a quantity of a component introduced under specified conditions. This makes the energy equation for a multi-component system take the form :

$$\mathrm{d}E = \Sigma X \mathrm{d}x, \qquad (9a)$$

and by Lagrangian transformations many useful subsidiary equations, including those in $\mathrm{d}G$, are at once obtainable. In the absence of radiant energy such a form may usually be specified.

With the work of Thomson and Clausius outlined above, classical thermodynamics may be said to have reached maturity. Thomson in 1898 showed, in fact, that all the fundamental equations may be stated in terms of E and F, defined as above. In 1864, however, Clausius introduced another derived function S, which he called the entropy. This is quite useful and is given by (2) as :

$$S = \mathrm{d}w/\mathrm{d}T = -\mathrm{d}F/\mathrm{d}T, \qquad (10)$$

and hence from (4) by :

$$\mathrm{d}S = \delta q/T \qquad (10a)$$

in reversible processes. It is seen that F and G are expressible in the forms :

$$F = E - TS\,; \; G = E - TS + pV. \qquad (11)$$

Since F decreases in irreversible changes, S increases ; in equilibrium F is a minimum at constant volume and temperature and S is a maximum at constant energy. S cannot claim to be more fundamental than F, and was introduced rather late, when most of the derived equations of thermodynamics were familiar.

The first applications of thermodynamics to chemistry go back to Horstmann, who, from 1869, used it in studies of dissociation. The most important pioneering work in this field, however, is that of van't Hoff in 1885. He not only carried over the equations for ideal gaseous systems to ideal solutions, but also gave equations for the work done in reversible

chemical changes in such systems, and the change of equilibrium constant with temperature. Van't Hoff made use of cyclic processes, in which selectively permeable membranes are employed to separate the constituents of mixtures. All subsequent developments of chemical thermodynamics show the influence of van't Hoff's work.

Thomsen in 1854 and Berthelot in 1864 had suggested that, in chemical changes:

$$w = -\Delta E;$$

and although this is seen to lack general validity from the point of view of equation 4, it is found experimentally to be approximately true in so many cases that some relation between ΔE and w, or alternatively between E and F, not contained in the two laws of classical thermodynamics, may be suspected. Such an approach, on the basis of experiment, is apt in many cases to disclose new laws, and is abundantly more fruitful than arguments based on symbolic equations. It was Nernst in 1906 who disclosed this new relation, called after him the 'Nernst heat theorem'; since it has limitations, the name 'third law of thermodynamics' sometimes used for it is unsuitable. The theorem states that in reactions between pure solids:

$$\mathrm{d}w/\mathrm{d}T = 0 \text{ when } T \to 0, \qquad (12)$$

when (4) shows that $\Delta E = -q_v$ is equal to w. Equations 3 and 10a then show that:

$$\Delta S = 0 \text{ when } T \to 0. \qquad (13)$$

A special case, in which S for every reacting solid is zero when $T \to 0$:

$$S = 0 \text{ when } T \to 0, \qquad (13a)$$

was proposed by Planck in 1911. Even if this is not true, we have no means of finding the absolute entropies at $T = 0$, and (13) shows that they are irrelevant in calculations; hence Planck's form is now always used. It at once enables S for any material to be calculated for any state (solid, liquid, or gaseous) from specific heats only, by integration from $T = 0$, when all specific heats are seen from (13a) to be zero. From S and known values of ΔE, the values of ΔF may be calculated. When these are known, the equilibrium constants of chemical reactions may be found by an equation deduced by van't Hoff in 1885, which, with suitable standard states, may be written in the form:

$$-\Delta G = RT \ln K \qquad (14)$$

for ideal gases or ideal solutions, where $\ln K$ is the natural logarithm of the equilibrium constant. A whole field of chemical thermodynamics is thus opened out.

A useful subsidiary function introduced by G. N. Lewis in 1907 enables (14) to be carried over to non-ideal systems. Instead of using the concentrations in K, it is possible to introduce quantities called activities which are functions of concentration, $a = fc$, where f is an activity coefficient. Lewis derived his equation by cyclic processes, which have always proved attractive to discoverers of new principles in thermodynamics, but the most convenient form is:

$$\mathrm{d}\mu = RT \ln a, \qquad (15)$$

where μ is the chemical potential. From (15) the equations of Lewis's scheme may be derived.

In the latest, modern, phase of thermodynamics, Thomson was also a pioneer. Both he and Maxwell clearly realized about 1870 that, when the atomic constitution of matter is brought into the picture, the second law of thermodynamics loses its general validity, since processes involving individual molecules which violate it, without disagreeing with the first law, can be imagined. The second law is true for systems composed of very large numbers of molecules, which behave like large populations and for which predictions based on statistical principles or probabilities can be used. Thus it is true only in a statistical sense. The development of this idea by Boltzmann and Planck led to a new science, statistical mechanics, which supplements the classical second law and limits the range of validity of the Nernst heat theorem. In this region, alternative types of statistics apply. Maxwell–Boltzmann statistics, based on classical mechanics, applies with close approximation in most cases, though probably never exactly, while in systems subject to laws governing quantum, as contrasted with continuous, energy changes, new types of statistics are used. One of these, due to Bose and Einstein, gives Planck's radiation formula. At present, the close relation of thermodynamics to statistical mechanics makes it desirable to deal with both in a text-book on thermodynamics, although statistical mechanics has many applications outside that subject.

All the equations of thermodynamics apply only to reversible processes. All real processes are more or less irreversible, and will be represented by inequalities, conformable with the condition that the free energy will be decreasing, or the entropy increasing, more than for a reversible change. A locomotive drawing a train at high speed with the regulator valve fully open is wasting much energy in friction, which is greater the higher the speed. In running up a gradient, the speed drops and, since there is less friction, the efficiency increases. The maximum efficiency is reached when the gradient is so stiff that the train is on the point of stopping, and all reversible processes, which are successions of equilibrium states, take place infinitely slowly, since they never really take place at all. Time has no place in classical thermodynamics.

Some reversible changes are, by their nature, always accompanied by irreversible ones. In his treatment of thermoelectricity, Thomson assumed that the reversible Peltier and Thomson effects could be treated independently of the irreversible Joule effect of heat production due to resistance, and similar assumptions have been made elsewhere. Since the results agree with experiment, they must be justified. It is only quite recently, however, that an attempt has been made to systematize such procedures in the case of steady states, when as much heat is entering an element of the system as is leaving it in the same time. The irreversible generation of entropy in the system due to the flow of heat is then known. One approach seeks to combine equations 9a and 10a, X being a generalized force and x being replaced by a rate of flow in steady states. A linear relation is assumed (which will not be true in some cases) and the general form is a tensor, which may be symmetric. If it is assumed that a temperature exists in every volume element, an equation giving the rate of generation of entropy as the sum of the products of the generalized forces and generalized flow-rates, divided by the temperature, is obtained. The subject is important, and a promising start has been made, which has proved useful in several fields. This is the newest phase of thermodynamics.

The books referred to below* deal with the applications of thermodynamics in chemistry; but that by Denbigh is of wider interest. They are all good and useful and can all be warmly recommended. Allard's book is very clear and interesting, starting at the beginning and deducing the equations from the fundamental laws. It has a fairly long section on the phase rule, which seems out of place, a good section on statistical mechanics, and a clear account of such parts of wave mechanics as are needed in this. The treatment is modern and the mathematics has been presented in an understandable form. It is a book very suitable for students.

The books by Rossini and Paul are based on the Lewis system; fugacity is rather fully dealt with by Rossini but only in passing by Paul. Both books attempt to start at the beginning. Rossini makes heavy weather of free energy by approaching it from entropy, and has more than a page in finding what is equivalent to equation 6 above, at the same time making it clear that ΔG is only part of the free energy change, a point not always evident in American books. Rossini's definitions are careful and clear, but it is not obvious why he should bring in atomic energy in such detail, since thermodynamics does not deal with nuclear changes. In both books the symbol F is used for G, and it is called free energy, which is confusing. Rossini, as might be expected, lays particular emphasis on experimental data, and his accounts of the calculation and use of thermodynamic quantities are admirable. He has not much to say of irreversible processes. Paul gives the usual treatment based on Clausius, which is not very clear; he could with advantage have reconsidered this topic, since he obviously has the capacity for understanding difficult subjects and making them clear to students. Both Rossini and Paul deal with the Debye–Hückel theory of strong electrolytes, but only Rossini deduces the equations. Both books deal with statistical mechanics, Paul's account being more readable and likely to be more intelligible to beginners. Both have problems, and Paul's gives answers. A section at the end of Rossini's book deals with the applications to such technical problems as fractionation, which should be useful to young chemists entering industry and called upon to put their knowledge into practice. In short, the books by Paul and Rossini are sound treatises written on American lines and bringing Lewis and Randall up to date.

Denbigh's book, I think, is not quite successful. It deals in a limited space with a rather difficult subject. It makes several re-starts on the same topic, which leaves the impression of a certain breathlessness, the i and k subscripts on pp. 27–29 are confusingly jumbled, and some of the statements, such as the one on p. 61 that both energy and entropy in thermodynamics are simply mathematical quantities, are rather startling. The real meaning of the heat of transport is not made very clear at the start, and the introduction of time into thermodynamics is not justified; the procedure of converting an equation into a kinetic equation by dividing by dt (p. 46) requires more justification, and the statement that de Donder's treatment of thermodynamics is better than Lewis and Randall's (p. 45) would not be approved by Allard, who shows in his book (p. 198) that it has some undesirable features; and is also clear (p. 72) that the application of the principle of increase of entropy to a 'universe' is meaningless unless the universe is defined as a thermodynamic system, which is not done by those using the idea.

The subject of thermodynamics has developed very much in recent years, and much of this has come about by reason of its applications in chemistry. The chemist needs to know what is contained in such books as the above, and it would do the physicist and engineer no harm to know it either. The method of treatment suitable in the study of heat engines is less applicable in chemistry, and the special methods used in that science have amplified the scope of the subject and have also provided a bridge between classical thermodynamics and statistical mechanics which has led to many valuable interchanges of material from the two sciences. The study of irreversible changes still remains undeveloped and difficult; but the material summarized in Denbigh's book shows that progress is being made in this field, and we may hope that before long many new fields of application will have been developed. Let those who think that thermodynamics is a closed subject reflect.

J. R. Partington

* Éléments de thermodynamique chimique. Par Georges Allard. (Bibliothèque d'Éducation par la Science.) Pp. 472. (Paris: Albin Michel, 1951.) 1380 francs.

Chemical Thermodynamics. By Prof. Frederic D. Rossini. Pp. xix+514. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 48s. net.

Principles of Chemical Thermodynamics. By Prof. Martin A. Paul. (International Chemical Series.) Pp. viii+740. (London: McGraw-Hill Publishing Co., Ltd., 1951.) 64s.

The Thermodynamics of the Steady State. By Dr. K. G. Denbigh. (Methuen's Monographs on Chemical Subjects.) Pp. vii+103. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1951.) 6s. 6d. net.

MOISTURE RELATIONS AND FIBRE PROCESSING

During the morning of September 9 at the recent meeting in Belfast of the British Association, Section A (Physics) held a session on the moisture relations of textile fibres, which consisted of two papers, one by Mr. J. A. Matthew, head of the Spinning Department of the Linen Industry Research Association, entitled "Moisture Absorption by Fibres and its Effect on Fibre Properties", and the other by Dr. A. B. D. Cassie, director of research at the Wool Industries Research Association, entitled "Moisture Relations and Clothing Comfort".

Mr. Matthew dealt with three main aspects of the problem. He discussed the relation between the amount of water absorbed by textile fibres and the atmospheric temperature and relative humidity, and also the effect of the absorbed water upon the physical properties of the fibre. He then gave some practical examples of the effect of humidity on the efficiency of the processing of flax fibres and yarn during spinning and weaving.

If fibre, yarn or cloth is stored in an atmosphere maintained at a constant temperature and relative humidity, the moisture content of the material, expressed as a percentage of the oven-dry weight, gradually attains a steady value called the 'equilibrium regain'. The equilibrium regain of all textile fibres and their products depends primarily on the relative humidity and temperature of the air, but other factors, including the previous history of the material, also have their effect. If the material is wetted out and then allowed to reach its equilibrium regain at a constant temperature and at a series of progressively decreasing relative humidities, the regain values lie on a sigmoid desorption curve when plotted against the relative humidity. When the process is continued

with ascending humidities, the regain values lie on a second sigmoid absorption curve which lies below the desorption isotherm curve, except at very low and very high humidities. A similar hysteresis effect occurs when absorption takes place as a result of increasing the humidity after partial desorption or when desorption occurs after partial absorption. Hysteresis also occurs when the material is brought to equilibrium in an atmosphere of constant humidity at temperatures which are progressively increased and afterwards decreased.

These effects are shown by the following materials: cotton, flax, hemp, jute, etc.; wood, silk and hairs; fibres manufactured by the regeneration of cellulose; and some other materials such as wool and starch. For all these materials the absorption and desorption isotherms are very similar in shape, so that the ratio of the equilibrium regain of one material to that of another is very nearly the same at all humidities.

A few manufactured fibres such as cellulose acetate, nylon and 'Terylene' do not behave in this way. There is no point of inflexion in the curve at low humidities, the regain is quite small at all normal humidities, and there is very little difference between the absorption and desorption isotherms.

The equilibrium regain at given atmospheric conditions differs from one type of fibre to another. For example, at 65 per cent relative humidity and 65° F. (18·3° C.) average values are as follows: wool 14 per cent, viscose rayon 13 per cent, green flax 11 per cent, silk 9·5 per cent, raw cotton 8 per cent; but with all natural fibres the equilibrium regains of different lots differ according to their origin and treatment.

The physical and mechanical properties of textile fibres depend upon the humidity of the air to which they have been exposed, and Mr. Matthew went on to deal with these effects in detail. The strength of fibres and of the yarns and cloth manufactured from them depends upon the humidity of the atmosphere in which they have been conditioned. Vegetable fibres usually increase in strength with increase in relative humidity, whereas the reverse is the case with artificial and protein fibres; for example, linen yarns increase 25 per cent in strength when the humidity is increased from 50 to 90 per cent, whereas viscose rayon loses 40 per cent of its strength under similar conditions. The moduli of elasticity and rigidity of fibres decrease with increasing relative humidity. The frictional properties of textile fibres and yarns increase rapidly with increase in humidity; but in most cases there is a reduction in the friction when a free film of water is present. The electrical properties of fibres and their products vary considerably with the regain. The conductivity of fibres is extremely low at low regains but increases very rapidly with increasing regain, while the dielectric constant remains fairly constant at low regains but thereafter increases rapidly with increase in regain. The variation in the electrical properties with regain forms the basis of electrical moisture meters; and, although the accuracy of these instruments is limited by differences between the behaviour of different batches of the material and a separate calibration is required for each type of fibre, the rapidity with which these instruments can be used more than offsets these disadvantages.

The absorption of water vapour by flax and other textile fibres and the consequent effects on their physical properties affect textile technology in many ways. After pointing out the need for control of the relative humidity in checking the weight per unit length of the yarn or the weight per unit area of the cloth, and the strength of the product, Mr. Matthew gave some examples taken from the spinning and weaving of linen, in which the atmospheric humidity has an important effect upon the efficiency of processing. In preparing flax fibre for spinning, the material passes through a number of frames on which it is drawn out by pairs of rollers rotating at different speeds. Fibre is liable to collect or 'lick-up' on these rollers, and when this happens the machine must be stopped for cleaning and so production is lost. 'Lick-up' can be considerably reduced by maintaining the flax at a suitable regain. In dry spinning, productivity is limited by breakages of the yarn, and the rate at which these breakages occur is much reduced by increasing the relative humidity. Similarly, in weaving, stoppages due to breakages of the warp yarn are reduced when the operation is carried out at a high temperature and humidity. Such atmospheric conditions, however, cause fatigue and discomfort to the workers, with a consequent reduction of output, so that in practice a compromise must be sought between the conditions which are most suitable for processing and those which are comfortable for the workers.

Dr. Cassie dealt with the thermal properties of clothing and showed how the interaction of the fibres with the water vapour in the atmosphere contributes in no small degree to the comfort of clothing by liberating heat when the wearer passes from a warm dry atmosphere to a cold damp one. Considering the thermal insulation, Dr. Cassie said that still air is the best insulator known to man, and fabrics make use of this property. The thermal conductivity of fabrics increases with their bulk density, and any increase in the amount of solid material of a fabric leads to a loss of heat insulation. Worsted fabrics contain about 60 per cent air, and the very large total surface area of the fibres—about 2,000 sq. ft./lb. of wool—exerts a very effective drag on the air, which is thus maintained at rest within the fabric and provides excellent heat insulation.

The large surface of the fibres brings them into close contact with the surrounding atmosphere and enables them to interact with the water vapour. Recent research has shown that in such conditions the time required for water to diffuse from the surface to the centre of a fibre is always negligible compared with the time required for the diffusion of water vapour and the transfer of heat through the air entrapped by the fibres. Fibres can react rapidly with heat and water vapour provided that they are presented to the fibre as quickly as required. On the other hand, at normal atmospheric conditions such as 65° F. and 60 per cent relative humidity, each c.c. of wool contains eighteen thousand times as much water as does the same volume of air, and this enormous difference between the water content of wool and air makes the approach to equilibrium slow when there is a relatively large bulk of wool.

The absorption of water vapour by fibres is accompanied by a large evolution of heat, and Dr. Cassie gave as an example the amount of heat liberated by a man's clothes when he goes out of doors from a well-ventilated and -heated room on a typical winter day in Britain. Assuming that the clothes contain five pounds of wool and that they are in equilibrium with the conditions indoors (namely, 65° F. and

45 per cent relative humidity), they will absorb one pound of water when taken outside and allowed to re-condition at 40° F. (4·4° C.) and 95 per cent relative humidity. In so doing they will liberate 1,200 B.Th.U. of heat. This amount of heat will provide excellent protection against the chill of a sudden temperature change provided that it is liberated at a suitable rate, and Dr. Cassie proceeded to show that the conditions within a fabric are such as to ensure that this heat is liberated at the optimum rate for protection against a sudden change of temperature.

The fibres are always in equilibrium with the air immediately surrounding them because absorption and desorption of water take place very rapidly; but the amount of water vapour absorbed from the air is so small compared with the water content of the fibres that their regain is virtually unchanged. The temperature of the air issuing from a mass of wool is therefore determined by the condition imposed by the fibres, namely, that the relative humidity must remain unchanged. The heat obtained by condensing enough water vapour from any given volume of air to maintain a constant relative humidity when its temperature is decreased by 1 deg. C. is roughly equal to the heat required to raise the temperature of the air in the given volume by 1 deg. C. Thus, if the temperature of the air coming into contact with the textile is reduced by 10 deg. C. without change in the water vapour pressure, the air after passing through the textile will only be reduced by 5 deg. C., enough water having been condensed from the air by the textile to raise its temperature by 5 deg. C. This thermostatic effect of textiles is maintained over considerable periods because, fortunately, the diffusion constants for heat and for water vapour are almost the same, being 0·21 cm.²/sec. and 0·25 cm.²/sec., respectively. Thus the temperature and water vapour gradients are correctly maintained for securing the maximum effect in reducing the chill produced by a decrease in temperature.

The results of experiments designed to test the accuracy of these theoretical conclusions were then described by Dr. Cassie, who showed that excellent quantitative agreement has been obtained between the theoretical and actual results. The effect was studied of increasing the temperature of the air, passing through a mass of fibre, from 20° to 35° C. without change of vapour pressure, and it was found that the change in temperature of the emerging air was halted at 26° C. The subsequent rate of increase in temperature was small, being least of all for wool and increasing in the order, wool, flax, silk and cotton. This corresponds to the order of the regains of the fibre, and, as predicted by the theory, the protection afforded by the fibres increases with the slope of the regain – relative humidity curves.

Finally, Dr. Cassie pointed out that a similar large thermostatic effect can result from textile furnishings. The increase in regain of a carpet when a room is left unheated results in the liberation of as much heat as would be given off by a 1-kW. electric fire burning for 1½–2½ hr., the heat being liberated over a period of several days.

In the discussion which followed these two papers, Dr. R. W. Powell described experiments made at H.M. Norfolk Flax Establishment on the moisture relations of the growing flax plant, and pointed out that the normal date of pulling flax corresponds to the time at which the whole plant has a uniform moisture content. He mentioned experiments made on the heating up of stacks of flax straw and also described how the humidification of dry flax straw before scutching increases the yield of flax fibre.

Miss M. V. Griffiths asked whether the airing of domestic linen is really necessary, as a large amount of electricity is being consumed in modern houses for this purpose. Should the air movement be increased during drying in an airing cupboard or could a more efficient drying cupboard be designed? In reply, Mr. Matthew said that he regarded airing as a safety measure; linens stored in a folded condition in drawers would have little access to free air and so would not dry if they were put away damp. The rate of drying increases with increasing air velocity and temperature; usually the most economical method is to use some heat and a definite but not necessarily very large air velocity, on well exposed material. Dr. Cassie said that it is necessary for underwear to be dried to a low regain; measurements have shown that, in the absence of perspiration, the air between the skin and underclothing has a relative humidity of only about 20 per cent, and underclothing should therefore be conditioned to this relative humidity by airing.

J. L. Spencer-Smith

AFFORESTATION OF MOORLAND

At the meeting of the British Association in Belfast, Section K* (Forestry) devoted a session during the morning of September 8 to the consideration of sylvicultural problems resulting from recent large-scale planting on moorland soils. The need for a considerable extension of the forest area in Britain —a need admitted by men of all shades of opinion— has led to the formation of large plantations on heathland and moorland mainly in the upland regions. The current annual planting programme, in State forests alone, of approximately sixty thousand acres requires the use of large areas of these types of land, and work has been going on actively since 1919 in such diverse conditions as those afforded, for example, by the Yorkshire moors, the peat-covered Border country, the upland heaths of north-east Scotland, of Wales and of south-west England, and the blanket bog of the north-west of England. In forming their plantations, foresters had little to guide them at first except the existence of one or two relatively small plantations, the history of which had been recorded. They have had to hammer out their own technique. The need for carefully conducted experimental work was early recognized, and the large number of experiments carried out in the west and in the north, covering a wide range of subjects, such as choice of species, methods of planting, ploughing, drainage and the use of fertilizers, has had a marked influence on the course of events.

J. M. B. Brown (Forest Research Station, Alice Holt), in a paper on "The Role of Indicator Plants in Moorland Afforestation", discussed the use of the natural flora of moorlands and heathlands as a guide in the selection of tree species for planting. The vegetation on the ground before planting has been extensively used during the past thirty years for determining what land is plantable and what is unplantable and for allocating tree species to the various sites. Interpreted with discretion, the natural flora may give useful information by indicating which species of tree appears to be suitable to the local

conditions of soil and climate. In Great Britain, however, there is, even now, comparatively little evidence which helps to correlate the performance of trees throughout their life-time with the vegetation at the time of planting. The difficulties of the problem have been greatly increased by the use of exotic conifers in moorland afforestation, for many of these trees have been widely used only during the past thirty years and some of them have scarcely been studied ecologically in their native habitats. The natural vegetation may also suggest the kind of difficulty to be expected in establishing trees on the site and the degree to which individual species will be susceptible to these difficulties. Here, there is much more experience which may safely be relied on, but the occasional inconsistencies which occur emphasize the need for caution in making broad generalizations. The character of the vegetation has been little used as a guide in deciding which types of moorland should be ploughed before planting, as the use of the plough has now become general. Nevertheless, an examination of the plant community present before ploughing will usually tell what is likely to succeed it after ploughing and how rapidly the changes will take place. This is important in assessing the competition which the young trees will have to face.

Trees which will ultimately give a good account of themselves on moorland may be very difficult and costly to establish; on the other hand, trees which are comparatively easy to establish may not prove adapted to conditions in later life. Both the long-term and the short-term aspects must be kept in view.

The classification of moorlands for afforestation should not be based wholly on the occurrence of a few familiar and easily recognized dominant plants, which, because of their wide tolerance, may be apt to mislead. Regard must also be paid to the less-conspicuous associates, to notable absentees, to the height, luxuriance and health of the dominants, and to evidence of disturbance by grazing, burning and peat-cutting.

"Recent Work on the Problems of Moorland Afforestation" was discussed in a paper by J. W. L. Zehetmayr (Research Branch, Forestry Commission, Edinburgh), who stated that one of the main functions of sylvicultural research at the present time is to increase the area of 'plantable' land by making it possible to afforest land which is at present classed as 'unplantable'. This may also have the effect of improving production on ground already regarded as suitable for planting. Experimental plantations, made at various times since 1921, have, in many cases, served as pilot schemes which have since been followed by extensive plantations on ground that was originally regarded as of doubtful value for forestry. In other instances, experimental plantations, though tolerably successful, have not yet inspired sufficient confidence for more widespread application of their results; examples of these may be found on deep basin peats and on thinner slope peats in the north-west of Scotland.

In the afforestation of peat, the first consideration is drainage, and drains are now invariably used to provide turves in which the young trees are set in planting. It was shown in early work that the more turf a plant has round about it, the better it grows. The provision of more turf for each plant led to more surface-draining by ditches, but so long as all the work had to be done by hand the economic limit was soon reached. Nowadays the draining plough is used to provide a continuous strip of upturned turf on which planting can be done. This has given satisfactory growth; but the system of equally sized drains, one alongside each row of plants, raises difficulties in subsequent maintenance, while the drains do not run sufficient water to clean themselves. One solution is to use two ploughs, a large plough such as the 'Cuthbertson' to make the main drains, and a lighter, shallower plough, like the 'Begg' or the 'Haddington', to provide material for turf-planting. The use of mechanical methods has decreased the quality of the work, as it is less easy with machines to site the main drains correctly. The Norwegian method of making very large deep drains at wider intervals and of using explosives in their formation is now receiving attention in Great Britain. It may have uses on land where ploughing is impossible.

Draining is not a problem on the heaths, most of which lie in the drier, eastern half of Britain; but ploughing, which is now the standard practice on these sites, leads to the disappearance of surface water which often lies long, while the rupture of the pan allows water to percolate through the soil so that no drains for removing water from the area are necessary. Ploughing has greatly improved the early growth of trees on heathland. The current method of ploughing is to cut a deep furrow every five feet with a heavy plough which breaks the pan and throws up a ridge of spoil. Other methods, such as complete ploughing to a less depth, and the use of a 'tine' plough, are being tried experimentally. An important advance is the introduction of the hydraulic-lift tractor, which greatly increases ease of manœuvring and allows the plough to be lifted over boulders and rock outcrops. On difficult sites it is usual to apply ground mineral phosphate or high-grade basic slag at the rate of 1½-2 oz. to each plant. Recent work by E. M. Crowther has shown that nitrogenous fertilizers improve the growth of newly planted trees on heathland.

On difficult or on marginal sites it is important to use the best 'strain' or 'race' of the tree which is selected for planting. One aspect of this was dealt with by J. A. B. Macdonald (Forestry Commission, Dumfries) in his paper on "The Place of *Pinus contorta* in British Sylviculture". This pine, a native of western North America, has come into prominence lately as a result of its success as a planted tree on poor peat and heathland sites. It has a wide range in North America, along the Pacific coast from Alaska to California, and inland into the Rocky Mountains. With such a range of altitude and latitude it naturally varies, the two extreme forms being recognized as the beach or shore pine, *P. contorta* Dougl. ex Loud, and the inland lodgepole pine, *P. contorta* var. *latifolia* Engelm. The former is a strong-growing coarsely branched tree, with dark green foliage, which throws a comparatively heavy shade; the latter has normally a straighter stem, finer and more open branches, and thinner, yellowish-green foliage. Sylviculturally they have rather different effects.

Various provenance trials of *Pinus contorta* have been planted in different parts of Great Britain, and preliminary assessments of the different plots show that coastal lots from Oregon and Washington grow fastest, while there is a suggestion that, if the whole range of the tree along the Pacific coast is considered, plants from the northern part of this range grow more slowly in Britain than plants from farther south

With the inland forms, the opposite may prove to be the case. The longest branches appear to grow on trees from the most northerly Pacific coastal origins, while the shortest branches tend to grow on trees from inland regions in the south. Generally there are more branches per whorl on the coastal forms. The coastal trees have shorter needles, averaging 1¾ in., while inland forms have needles averaging 2–2½ in. in length; the inland lodgepole pine does not hold its needles as long as the coastal form, on which needles are retained for three years or more. All the trees of coastal origin have completely, or almost completely, killed out the ground vegetation; but very little suppression has been effected by inland forms.

These papers were preceded by an account by James Macdonald (director of research and education, Forestry Commission) of recent developments in forestry nursery technique. The success of a large planting programme depends on a continuous supply of suitable planting stock, and thus the raising of plants in the nursery has always been regarded as of prime importance. Various difficulties have been encountered in running nurseries at high pressure for the provision of young trees, almost entirely coniferous; during the nineteen-thirties, for example, there was a serious diminution in the fertility of many nurseries. One approach to the solution of this problem was made by the late Dr. M. C. Rayner, who established at Wareham, in Dorset, a nursery which made an important break with established practice. Instead of using an agricultural soil, Dr. Rayner set to work on a piece of uncultivated heathland and, by shallow cultivation, subsoiling, and a liberal use of composts, produced successive crops of seedlings much larger than had ever been raised before. Her technique, with various modifications, was widely used elsewhere, and a considerable proportion of the seedlings produced to-day are grown in 'heathland' nurseries. These nurseries, when properly sited and managed, are remarkably free from weeds, and the saving in weeding costs is an important item to be set off against the expense of the other operations. This technique did not solve the problems of the ordinary forest nursery; it avoided them. They were approached, however, from another side; by means of partial soil sterilization, with steam, with formalin and with other chemicals, combined with appropriate fertilizer treatment, nursery soils which had been producing very poor seedlings began to yield plants as good as those in heathland nurseries, while there was also a substantial reduction in weeding. The complex of factors involved in this and in other nursery processes is being studied by a committee which was set up by the Forestry Commission in 1944, under the chairmanship of the late Prof. F. T. Brooks, and on which Drs. E. M. Crowther and A. B. Stewart are active members. It has been found possible to raise with fertilizers seedlings as good as those produced with the aid of compost or sterilization; it has also been established that many conifers, and particularly Sitka spruce, are highly sensitive to lime in the nursery and that some of the trouble in the established nurseries was due to injudicious liming. Because it is possible to raise seedlings which can be handled at the end of their first year, it has been possible to use many more two-year-old transplants in moorland afforestation. These are less costly than the three/four-year old plants formerly used.

The prospect of effective weed-control in seed-beds has been brightened by the use of mineral oils applied before the tree seedlings emerge, while other directions in which research is proceeding are in the use of overhead irrigation and in the attempt to raise two or three successive crops of seedlings in a season with the help of bottom heat.

NEWS and VIEWS

Physiology in the University of London: Prof. Geoffrey Harris

Prof. Geoffrey Harris, who has been appointed to the Fitzmary chair of physiology in the University of London, is known for his work on the control of the pituitary gland. This chair, of which he is the first holder, is named after Simon Fitzmary (1492), the founder of Bethlem Royal Hospital; it is attached to the Department of Neuro-Endocrinology of the Maudsley Hospital. Prof. Harris was first trained in anatomy and medicine in Cambridge, and, after qualifying at St. Mary's Hospital, London, became in 1940 demonstrator and later lecturer in anatomy at Cambridge; in 1948 he was appointed lecturer in the Department of Physiology. His research work has been on the anatomy and physiology of the pituitary gland and on the control of pituitary secretions by the nervous system. In his recent work he has modified the technique of implanted electrodes and placed small secondary coils under the scalp with an electrode placed in various sites near the supra optic nuclei. By using a primary coil surrounding the animal, he was able to produce endocrine effects on urine flow, œstrus, etc., without otherwise disturbing the animal. He has shown the existence of a hormonal link, carried by a system of portal vessels, between the nervous and secretory structures. The pituitary forms the main link by which external events affect the endocrine glands via the nervous system, and this clarification of how this is effected helps in our understanding of both. His work is characterized by great skill in difficult operative techniques and in masterly grip of the physiological and anatomical problems of his chosen field. Prof. Harris's many friends will be glad that in his new post he will be able to devote himself almost entirely to research in this rapidly developing field, in which he has done so much to clarify our ideas during the past fifteen years.

H. G. Smith (1852–1924): a Pioneer Australian Chemist

An interesting centenary has recently been observed in Sydney, marking the birth on July 26, 1852, of Henry George Smith, a pioneer worker on the chemistry of the Australian flora. Smith was born at Littlebourne, in Kent, and emigrated to Australia in 1883. He amplified his scanty scientific training while holding a humble post at the Sydney Technological Museum, and in 1891 published his first original paper, announcing the discovery of barytes in the Hawkesbury sandstones at Sydney. In 1895 he became mineralogist at the Museum. An ensuing paper on eucalyptus kinos and the occurrence of

eudesmin, published in collaboration with J. H. Maiden, the botanist, heralded a long series of original contributions to the chemistry of Australian essential oils, exudations and other indigenous plant-products. In 1899 Smith became assistant curator and economic chemist in the Museum, and most of his work on the chemistry of the Australian flora was carried out in collaboration with R. T. Baker, curator and economic botanist in the Museum. Their *magnum opus*, "A Research on the Eucalypts, especially in regard to their Essential Oils", was published first in 1902 and again, in an extended form, in 1920.

Upon his official retirement in 1921, Smith became associated with the then recently founded Department of Organic Chemistry in the University of Sydney, where he pursued further work, partly in collaboration with Prof. John Read, on the chemistry of some of the substances, notably the eucalyptus ketone, piperitone, that he had isolated in earlier researches. Smith and Read had previously collaborated in an investigation of the so-called 'marine fibre' of *Posidonia australis*; the results of this lengthy research were issued in 1919 as one of the early publications of the Institute of Science and Industry of the Commonwealth of Australia. One of Smith's last investigations dealt with the possibilities of utilizing Australian wood fibres in paper-making. Altogether, Smith published more than a hundred original contributions to chemical science; sixty-two appeared in the *Proceedings of the Royal Society of New South Wales*, of which Smith was a modest but much-esteemed member. A meeting of the Sydney University Chemical Society held last August was devoted to terpene chemistry, with special tributes to Smith's life and work. Many of his original isolations, papers and photographs were displayed, and addresses were given by Prof. A. J. Birch, of the University of Sydney, and Mr. W. J. Dunstan, of the New South Wales University of Technology.

J. N. Langley, F.R.S. (1852–1925)

JOHN NEWPORT LANGLEY, whose signature is writ large in the history of the sympathetic nervous system, was born at Newbury a century ago, on November 2, 1852. In his second year at Cambridge, his interest in biology and physiology was aroused by Michael Foster, and he obtained a first class in the Natural Sciences Tripos in 1874 and three years later an open fellowship at Trinity College. His early research on the action of pilocarpine on the frog's heart was followed by a meticulous study, taking fifteen years, of the process of secretion in the mammalian salivary gland, in the course of which he distinguished between the 'loaded' and the 'exhausted' states of the gland. Foster had been made professor of physiology in 1883, and Langley, on being appointed in the following year as university lecturer in histology, became his assistant, succeeding him in the chair in 1903. During 1890–1906, helped by Hugh Anderson and W. H. Gaskell, Langley threw a flood of light on the sympathetic nervous system, his researches being a landmark in the history of physiology. He defined the autonomic system as an efferent system in 1903, and in 1921 published a book on the subject. He was working on the mechanism of excitation of cells when the outbreak of the First World War caused him and his depleted staff to pursue investigations of greater national urgency, such as the trophic changes in muscle and nerve following injury. In 1894 Langley paid off the debt which had long burdened the *Journal of Physiology*, and continued as owner and editor until his death. He was elected to the Royal Society in 1883 and vice-president in 1904. He died of pneumonia on November 5, 1925.

Regional Scientific Advisers for Civil Defence

THE organization of regional scientific advisers for civil defence in Great Britain, which has been set up by the Home Office, is now virtually complete. Many of the leading scientific men of the country have responded to the appeal of the Home Secretary and the Secretary of State for Scotland, and are giving their advice and assistance in this vital department of the country's defence organization. In each of the eleven regions into which England and Wales are divided for civil defence purposes, a group of these scientific men has been appointed, and similar appointments have been made in Scotland by the Scottish Home Department. It is understood that the Government of Northern Ireland will also shortly appoint scientific advisers. These scientific advisers serve in an honorary capacity in time of peace, and are accredited to the staff of the Chief Scientific Adviser of the Home Office, Whitehall, London, S.W.1. They also give their advice and assistance independently to the civil defence authorities in their own regions. An important step has thus been completed. In effect, a panel of scientific consultants has been formed so that the best scientific thought and experience can be applied both nationally and regionally to the problems of civil defence. At the present time the regional scientific groups are giving valuable assistance in the formation and training of the technical reconnaissance units of the Civil Defence Corps, the officers of which are required to have university qualifications or be members of the professional scientific institutions. The regional scientific advisers are arranging and supervising courses of scientific instruction for them at the universities in the regions, particularly in the physics of atom warfare and the chemistry of the war gases. The contacts between the advisers and the professional institutions are most advantageous; and the institutions themselves have already volunteered their help in directing the attention of their members in the regions to the need for qualified men and to the importance of offering their services.

The several regions, with their centres and senior and other scientific advisers, are as follows: *Northern Region* (*Newcastle upon Tyne*): Prof. W. E. Curtis, Prof. G. R. Clemo, Dr. G. H. Christie; *North Eastern Region* (*Leeds*): Prof. F. W. Spiers, Prof. W. Bradley, Prof. W. Sucksmith; *North Midland Region* (*Nottingham*): Prof. L. F. Bates, Dr. D. O. Jordan, Prof. L. Hunter; *Eastern Region* (*Cambridge*): Dr. B. C. Saunders, Mr. E. S. Shire, Dr. E. N. Fox; *London Region*: Sir Charles Ellis, Prof. W. V. Mayneord; *South Eastern Region* (*Tunbridge Wells*): Brigadier R. A. Bagnold, Prof. D. H. Hey, Dr. F. C. Champion; *Southern Region* (*Reading*): Dr. H. W. Thompson, Prof. R. W. Ditchburn, Prof. A. N. Black; *South Western Region* (*Bristol*): Prof. W. E. Garner, Prof. S. H. Piper; *Wales* (*Cardiff*): Prof. W. N. Thomas, Prof. F. Llewellyn Jones, Dr. S. T. Bowden; *Midland Region* (*Birmingham*): Prof. H. W. Melville, Prof. P. B. Moon, Prof. J. R. Squire; *North Western Region* (*Manchester*): Prof. E. R. H. Jones, Dr. G. D. Rochester, Prof. C. E. H. Bawn; *Scotland*: Sir Edward Appleton, Prof. N. Feather, Prof. J. W. Cook, Prof. R. V. Jones, Prof. D. H. Everett.

Oil Pollution of the Sea

A meeting of the Permanent Committee on oil pollution which was set up in June 1952 was held at the House of Commons on October 23, under the chairmanship of the Earl of Ilchester. Representatives of the following organizations which constitute the Committee were present: Association of Sea Fisheries Committees of England and Wales, Council for the Preservation of Rural England, International Committee for Bird Preservation, Royal Society for the Protection of Birds, Universities Federation for Animal Welfare, County Councils Association, Association of Municipal Corporations, Urban District Councils Association, Rural District Councils Association and the General Council of British Shipping. It was decided that the official name should be the Co-ordinating and Advisory Committee on Oil Pollution of the Sea (*Secretary:* Miss Phyllis Barclay-Smith, International Committee for Bird Preservation (British Section), c/o British Museum (Natural History), Cromwell Road, London, S.W.7). The meeting expressed gratification at the setting up by the Minister of Transport of a Government committee to investigate the problem, and it was agreed to offer this committee every assistance and co-operation, particularly with regard to providing factual evidence. The urgency of the problem was again stressed and the serious situation with regard to the pollution of small harbours was emphasized.

The clerk of Truro Rural District Council reported the results of an experiment carried out on St. Agnes Beach, Cornwall, during June 1–September 8, 1952. During these hundred days the beach, which is a small one of 160 yards in length at highwater mark, was cleared of oil deposits, which were weighed. The results showed that more than fifty-seven hundredweights of waste oil were washed up during this period, that is, an average of more than 64 lb. per day.

Greenwich Mean Time

The practice at the Royal Observatory, Greenwich, of dropping the Time Ball, the symbol of Greenwich time throughout the world, was resumed at 1 p.m. on October 26. The Time Ball is a dull red sphere, 5 ft. in diameter; it is part of the Wren Observatory building and was erected for the purpose of enabling masters of vessels proceeding down the Thames to adjust their chronometers. The Time Ball is raised half-way up a mast, on which it slides, at five minutes to one, hauled to the top at two minutes to one, and released electrically on the hour. It was the earliest means of making Greenwich mean time known to the public, but the system has now been superseded for all practical purposes by the six pips broadcast at fixed times by the B.B.C. and by the speaking clock operated by the G.P.O. The Ball was operated continuously from 1833, when first installed, until the Observatory was evacuated during the Second World War. Its operation was temporarily resumed at the start of the Festival of Britain, but it is now intended to continue dropping it as long as members of the Observatory staff remain at Greenwich. Instruments of purely historical interest, such as the Time Ball, will remain at Greenwich.

Meteorology and Agriculture

Sir Robert Watson-Watt, in his presidential address in 1951 to the Royal Meteorological Society, suggested a number of steps which might be taken to match meteorology to man's needs. One was for the Society to set up 'Interest Groups' for such subjects as agriculture and horticulture, fishing, education, transport and engineering. This suggestion has led to the initiation by the Royal Meteorological Society of its first Interest Group, on meteorology and agriculture and horticulture, under the leadership of Dr. G. L. Hogben. This development will be marked on the occasion of the second annual dinner of the Society on November 27, to be held in London, when the guest of honour will be Sir James Scott Watson, chief scientific and agricultural adviser of the Ministry of Agriculture and Fisheries and director general of the National Agricultural Advisory Service. He will be supported by distinguished representatives of agricultural science and practice and of meteorology.

Seismic Refraction Shooting in the Atlantic

M. N. Hill and J. C. Swallow have developed a method of seismic refraction shooting at sea using hydrophones at a depth of 100 feet below the surface of the sea, connected with sono radio buoys at the surface. Depth-charges exploded at a depth of 900 ft. send compressional waves through the sea and the rocks of the sea-bed. These *P*-waves are received on the hydrophones, and the records are transmitted to the ship by signals from the sono-radio buoys. Thus only one ship is necessary for the work. Experiments to test the method and to explore the sea-bed were carried out by Hill and Swallow from the Ocean Weather Ship *Weather Explorer* during August 1949, while the ship was occupying her routine position for meteorological observations at lat. 53° 50′ N., long. 18° 40′ W. The results have been written up by Hill alone (*Phil. Trans. Roy. Soc.*, A, No. 890, 244, 561; June 17, 1952; 7*s.* 6*d.*). The depth of water in this area of the eastern Atlantic is approximately 2,400 m., and below this Hill and Swallow found, as the result of the experiments, unconsolidated sediments of thickness 1,900–3,000 m. The velocity of *P*-waves in the sediments varied from 1·5 km./sec., nearest the water, to a limiting value of 2·5 km./sec. at depth. Below the unconsolidated sediments they also deduced the presence of crystalline rock to a depth of 2·7–3·4 km., through which *P*-waves travelled at 5·0 km./sec. Below this, to an unknown depth, they deduced the presence of rock which transmitted *P*-waves at 6·3 km./sec.

Overseas Information and Broadcasting Services

Replying to a question in the House of Commons on October 22, Mr. H. A. Nutting, Under Secretary, Foreign Office, said that the following committee has been set up to inquire into the overseas information and broadcasting services: Lord Drogheda (chairman), Sir R. Bruce Lockhart, Mrs. Mary Stocks, Mr. J. W. Platt, Mr. Gervas Huxley, Mr. Donald McLachlan, Mr. Victor Feather, and Mr. Laurence Heyworth. The terms of reference are: "To assess the value, actual and potential, of the oversea information work of the Foreign Office, Commonwealth Relations Office, Colonial Office, Board of Trade, and Central Office of Information; the External Services of the British Broadcasting Corporation; and the work of the British Council; to advise upon the relative importance of different methods and services in different areas and circumstances; and to make recommendations for future policy".

The Night Sky in November

Full moon occurs on Nov. 1d. 23h. 10m., U.T., and new moon on Nov. 17d. 12h. 56m. The following

conjunctions with the moon take place: Nov. 2d. 15h., Jupiter 7° S.; Nov. 15d. 06h., Saturn 7° N.; Nov. 19d. 03h., Mercury 2° N.; Nov. 20d. 11h., Venus 1° N.; Nov. 22d. 05h., Mars 0·2° S.; Nov. 29d. 17h., Jupiter 7° S. Mercury, an evening star, is too close to the sun for favourable observation and is in inferior conjunction on November 30. Venus is a conspicuous object in the western sky, setting about 17h. 55m. during the first part of the month and at 18h. 20m. on the last day; its stellar magnitude is − 3·5, and more than three-fourths of its illuminated disk is visible. Mars sets at about 20h. 05m. throughout November, stellar magnitude 0·9; but as its south declination is considerable, it does not rise very high above the horizon. Jupiter is visible throughout the night, setting in the morning hours at 7h. 40m., 6h. 30m. and 5h. 20m. on November 1, 15 and 30, respectively, and is a conspicuous object, stellar magnitude − 2·4, in the constellation of Aries; on November 8 the planet is in opposition to the sun. Saturn is a morning star, its times of rising being 5h. 10m., 4h. 20m. and 3h. 20m. at the beginning, middle and end of the month, respectively, stellar magnitude 1, and is easily recognized a little north of Spica. Occultations of stars brighter than magnitude 6 are as follows (observations being assumed to be made at Greenwich): Nov. 4d. 0h. 23·1m., χ Taur. (*R*); Nov. 8d. 1h. 57·8m., μ Canc. (*R*); Nov. 23d. 19h. 22·9m., 42 Capr. (*D*); Nov. 30d. 17h. 28·5m., η Taur. (*D*); Nov. 30d. 18h. 21·7m., η Taur. (*R*). *R* and *D* refer to reappearance and disappearance, respectively. The Andromedids and Leonids are due about November 14 and 16, respectively, but these meteor showers are now very weak and comparatively few meteors from them have been seen in recent years.

Royal Society of Edinburgh: Officers for 1952–53

THE following were elected officers and Members of Council of the Royal Society of Edinburgh at the annual statutory meeting held on October 27: *President*, Prof. James Kendall; *Vice-Presidents*, Prof. E. T. Copson, Prof. J. H. Gaddum, Sir Robert Muir, Prof. James Ritchie, Prof. R. C. Garry, Prof. W. M. Smart; *General Secretary*, Dr. J. E. Richey; *Secretaries to Ordinary Meetings*, Prof. J. Norman Davidson, Dr. John E. Mackenzie; *Treasurer*, A. W. Young; *Curator of Library and Museum*, Dr. Douglas Guthrie; *Councillors*, Prof. J. F. Allen, Prof. A. Murray Drennan, Dr. E. Wyllie Fenton, J. M. Ross, Prof. C. M. Yonge, Prof. Norman Feather, Sir Godfrey Thomson, Dr. D. P. Cuthbertson, Principal H. B. Nisbet, Prof. T. C. Phemister, Dr. J. B. Simpson, Prof. Meirion Thomas.

Announcements

DR. W. G. PENNEY, O.B.E., F.R.S., chief superintendent of the Armament Research Department, who has been responsible for the design and testing of the British atom bomb, has been promoted to be knight commander of the Civil Division of the Order of the British Empire (K.B.E.).

LORD RADNOR, who has been a member of the Forestry Commission since 1951, has been appointed chairman of the Commission in succession to the late Lord Robinson, who died on September 5.

THE 119th meeting of the American Association for the Advancement of Science will be held in St. Louis, Mo., during December 26–31. Besides the individual sessions of the eighteen sections of the Association, more than forty societies affiliated or associated with the Association will be concurrently holding meetings. Further information can be obtained from the director of public information, Sidney S. Negus, Medical College of Virginia, Richmond, Va.

THE British Scientific Instrument Research Association is holding open days at its laboratories at 'Sira', Southill, Elmstead Woods, Chislehurst, on November 5 and 6.

AN exhibition of Spanish scientific books has been arranged at the Science Museum Library, London, S.W.7, and will be open to the public during November 6–20.

A WORLD Congress of Medical Practitioners for the Study of the Actual Conditions of Life, which was to have been held in Montecatini during October 16–18 (see *Nature*, June 28, p. 1085), did not take place owing to the refusal of the Italian Government to authorize the meeting. The Congress authorities hope to hold it some time during the first half of 1953. Further information can be obtained from the secretary, Dr. C. Massenti, Corso Trieste 65, Rome.

AN exhibition entitled "Training for Industry", showing the work of the City and Guilds of London Institute, will be on view at the Goldsmiths' Hall, Foster Lane, Cheapside, London, during November 4–14, and will be inspected on November 3 by H.R.H. the Duke of Edinburgh, president of the Institute. The exhibition has been arranged in connexion with the Institute's yearly meeting, and among the features to be seen will be models of scientific and engineering equipment, including a supersonic wind-tunnel, from the City and Guilds College, South Kensington; students' work in fine arts and crafts from the City and Guilds Art School, Kennington; and a pictorial presentation of the work of the Institute's Department of Technology which covers nearly two hundred subjects.

THE Meldola Medal, which is the gift of the Society of Maccabæans and is normally awarded annually, is being offered for award early in 1953 to the chemist who, being a British subject and less than thirty years of age on December 31, 1952, shows the most promise, as indicated by his or her published chemical work brought to the notice of the Council of the Royal Institute of Chemistry before December 31. Communications should be addressed to the President, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1, the envelope being marked "Meldola Medal".

SIR GEORGE BEILBY Memorial Fund awards, which are considered by administrators representing the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Metals, are made at intervals to British scientific research workers, preference being given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering and metallurgy. In general, the awards are granted to younger men and women for original work done over a period of years. Awards may be made early next year, and the administrators request that their attention be directed, not later than December 31, to outstanding work of the nature indicated. All communications should be addressed to the Convenor of the Administrators, Sir George Beilby Memorial Fund, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

PROBLEMS OF THE SMALL FARM

THE three papers covering the problems of the small farm, given at Belfast on September 8 to Section M (Agriculture) of the British Association, differed in scope so widely that it was difficult at first to see how they fitted together; but on examination, it was possible to see a pattern which at least indicated some of the problems facing small farmers in the United Kingdom, without providing a ready-made solution for them.

Mr. Ronald Ede, agricultural attaché for Denmark, described the agricultural system in Scandinavia and the Low Countries. This account was particularly interesting because, although the average size of farm holdings in these countries is well below that of Great Britain, it is an accepted fact that the farming efficiency is high, and high-quality farm produce is exported at competitive prices in the world market. The second speaker, Mr. A. Cromie, a farmer in Northern Ireland, described his own farm—a typical small one in a country where the average size of farm is small—and gave his views on the problems facing farmers such as himself. The importance of his paper lay in the fact that he is a very progressive farmer. Finally, Mr. W. H. Cashmore, director of the National Institute of Agricultural Engineering, Silsoe, related the problems of mechanization to the size and type of farm and suggested that attention to organization, careful selection of equipment and further work on farming techniques would play their parts in extending the benefits of mechanization to the smaller farms.

In describing Scandinavian agriculture, Mr. Ede stated that nearly all land is owned by the farmers, but there is rigid government control of the size of small-holdings. Although the minimum size is five acres, the average is less than forty acres, and the tendency during the past thirty years has been to reduce both the number of large and small farms, and so raise the number of farms of average size, amalgamation of farms being prohibited. The labour is mostly family labour, and the majority of farms run on a mortgage at a low rate of interest. A smallholder with £250–500 capital can borrow up to £3,200, and the average level of borrowing is about £1,300.

The standard of living on the Danish farm is low compared with that in Britain, and smallholders are not replacing themselves because of the difficulties of finance. Many of the sons of smallholders move into industrial employment, the keenest demand for small farms coming from the sons of the medium-sized farms.

There is no State advisory service in Denmark, but advice reaches the farmers through the Smallholders' Association. Mr. Ede did not mention anything of special note about the cropping, except that there is a marked increase in fodder beet and a steady rise in fruit growing. The larger farms tend to grow the cereals for feeding-stuffs, and on the smallholdings grassland predominates.

Some machines, particularly the special and expensive implements, are handled on a co-operative basis. The standard of machinery at the homestead for handling cattle-food is high. The main features of Danish smallholdings are: small acreage (by British standards), good buildings that are well equipped, and dependence on borrowed capital. Even in Denmark there is some concern about the level of borrowed money, and it is realized that a fall in world prices would cause difficulties. In the discussion on this paper the mortgage position was the main topic. The general opinion was that the amount borrowed was high and, while it might be sound policy to raise money for current expenditure, it was risky to use borrowed capital for such items as machinery and buildings.

Mr. Cromie's farm is 37½ acres, of which 29½ is arable, and he rents a further 34 acres. His cropping is varied and includes small acreages of fodder crops such as marrow stem kale, fodder beet and arable silage; he also grows cash crops such as potatoes, ryegrass and oats, for seed.

The livestock consists of twelve Friesian cows and their followers, five sows and all their progeny, plus thirty to forty extra pigs each year, and some poultry. It was obvious that his stocking and production was well above average. The following examples illustrate the planning to raise the total output: the tractor had been equipped to do all the work, to the total exclusion of horses, thereby making it possible to carry two more cows; an analysis of the soil from various parts of the farm had indicated deficiencies which, when corrected, made it possible to carry more stock with an appreciable increase in the milk yield; a proportion of the grassland is ploughed out and reseeded each year to keep up the quality of the grass; silage-making is practised to conserve grass; and an electric fence is used for strip or controlled grazing.

Mr. Cromie confirmed the view that the production per acre can be higher on a small farm than a larger one because of greater personal attention and supervision. He was convinced that the output could be increased by 100 per cent if the results of agricultural science could be put into practice. "At the present time a good deal of scientific work does not reach the small farmer. Quite often, improved techniques required additional capital outlay, and Mr. Cromie stated that the greatest handicap to progress was the large amount of capital needed, especially for reconstruction of buildings.

Great interest was aroused by the statement that the standard of knowledge on the farm will have to be raised. In the discussion, Mr. Cromie explained that farmers are taking an increasing interest in the management of a farm and the application of scientific work, but that the farmer is often too tired at night to go to lectures, discussions, etc., after a long day of toil. He thought that there is need for greater effort in spreading knowledge of scientific and experimental work, and suggested that demonstration farms would help.

Mr. Cromie confirmed that a farmer and his wife can make a fair living from about thirty-five acres in Northern Ireland, but he himself was strongly in favour of extending the area farmed by a further thirty acres; this justifies the services of a hired man and makes possible an increase in livestock. He admitted that in practice the high rental of the extra land and the labour cost offset most, if not all, the extra income.

In the discussion it was suggested that specialization on a few crops might increase the overall output per acre, and the idea of installing a small grass-drier to provide concentrated food for the dairy cattle and for sale was put forward. The case against 100 per cent grassland on the small farm is that arable land helps to keep the farm clean, and provides some cash

crops such as potatoes and seed corn as well as by-products for livestock.

Mr. Cromie is without mains electricity, which is essential for a highly mechanized dairy and many of the appliances which support a 100 per cent grassland farm. In considering how far the use of machinery could assist the small farm, Mr. Cashmore stated that as the size of farm decreases below two hundred acres there is a marked upward trend in the capital invested in machinery per acre. His paper dealt with farms in the 50–150 acres class, on the assumption that below this level some specialization in cropping was necessary and so was outside the scope of this paper.

An analysis of capital invested in machinery and annual cash returns indicates that the greater use of machinery raises the yield rather than replaces regular labour. The margin of profit from increased mechanization is slender and very dependent on sound organization and proper maintenance. Even in the 50–150 acres class, capital expenditure on machinery increases as the size of holding decreases, but is justified by the higher returns per acre due to personal supervision and attention to detail.

In discussing how far expenditure on machinery could be kept down, Mr. Cashmore quoted from field surveys and investigations to show that in a number of cases the main advantage of a specialized machine is that it enables men to work a long day without undue fatigue. For short periods there is a slightly higher demand for labour; but the overall cost of the operation is no higher. On these grounds it could be argued that the small farm would gain nothing by purchasing these machines. The limitations of the co-operative use of machinery were stated; but where suitable contractor service is not available, there are possibilities in local farmers' co-operative societies for the use of certain expensive equipment. This system is already being employed in England for cereal harvesting and grass drying, and might be extended to ditching, hedge cutting, dung loading, etc.

Considerable emphasis was placed on better techniques and improved organization, and investigations were quoted to show that the efficiency of organization has a greater effect on the cost of a process than the design of the equipment. Commenting on general design, Mr. Cashmore stated that the small farm does not require scaled-down tractors or implements except in the case of barn machinery, which can be designed to run automatically provided electricity is available and the buildings are in good order. Already satisfactory equipment for the small farm has been devised, examples being milking machines and platform grain driers. It is possible that many more modifications or new developments would be helpful, but these must be related to technique investigations.

The discussion supported these views and emphasized the need for detailed studies to reveal whether the various problems could be solved by improved techniques, improvisation or new machines. It was thought that on the small farms the field equipment would have to be kept as simple as possible, with marked development of machinery for handling cattle food at the homestead.

In conclusion, the problems facing the small farmers are: shortage of capital, lack of knowledge on scientific work, poor farm buildings, and, in some cases, the wrong machinery. All these problems are interrelated, and, provided the size of holding is not less than 50–75 acres for general farming, it is reasonable to expect progress in the future.

W. H. Cashmore

CHEMISTRY IN ABERDEEN

By Prof. R. M. BARRER

CHEMISTRY was one of the first sciences to develop as a university study. In part for this reason, but still more because of its intrinsic interest and great practical value, the subject now attracts many students. University departments, often designed long ago to house smaller numbers, have in many centres become inadequate and outmoded. It is a feature of recent university development in Britain that serious efforts are being made to remedy this situation by rebuilding or by rehabilitating and extending existing chemistry departments. In Aberdeen, the University is now seeing the completion of a building first contemplated more than thirty years ago, and commenced in January 1949. The subject of chemistry has been removed from Marischal College, where it had been taught since the union of the two original Universities of Aberdeen in 1860, and has been rehoused on a site near the historic buildings of King's College. The new building was opened by Sir Robert Robinson on September 17. The newness of the department may render a brief description of the layout and facilities of interest to scientists and others concerned in the design of science departments.

The building has been constructed in the form of a cross. Four floors are devoted to chemistry, and a final floor to soil science and agricultural biochemistry, both subjects closely allied to chemistry and of considerable significance to the rich agricultural industry of Aberdeenshire. Each is under a separate head. All floors are served by a central staircase, and by subsidiary stairs at the end of the south wing. In addition, the building contains two lifts, of which one is designed for carrying goods and equipment. The building is a granite structure, the granite of several blending hues having been taken from six different quarries.

The lower ground floor of the building contains the main chemical and apparatus stores; mechanical, glassblowing and electronic workshops; a refrigerated room operating at adjustable temperatures down to $-10°$; and the electron microscope. There is in addition some research accommodation on this floor. In the east wing of the ground floor is situated the large elementary chemistry laboratory, with two balance rooms, one at each end. Associated preparation and subsidiary store rooms run into the south wing, which also contains research and staff rooms and a lecture room. This room is served by a large preparation room which also serves the main lecture theatre in the west wing. The theatre is excellently appointed and holds about 220 students. In the north wing are the main entrance hall, and large cloakrooms. Additional cloakrooms are available on every floor.

The first floor houses in the east wing the inorganic teaching laboratory with associated preparation and balance rooms. There is also a room especially provided for electrochemical work, and an inorganic research laboratory. In the west wing is a large research laboratory, and in the north wing a laboratory specially designed for larger scale chemical and physico-chemical operations. There is fume extraction from this room, which can be general or else can be concentrated at any desired point. In the same wing are a departmental library and staff room and further research laboratories. The south

wing houses the main chemistry library, an X-ray room, staff rooms, the professor's research laboratory and a third lecture theatre. The second floor contains, in east and west wings respectively, the organic and physical chemistry laboratories, each with associated balance room, preparation room and subsidiary store room. The west wing also contains research laboratories and two well-equipped dark rooms, one for staff and the other for student use. The north wing contains five optical cubicles associated with the physical chemistry teaching laboratory, an electrical instrument store and two constant temperature research laboratories. The south wing contains a laboratory for microchemical analysis and six additional research laboratories. On the third floor of the building one moves into the domain of soil science and agricultural biochemistry. These subjects share a teaching laboratory and preparation and balance rooms in the north wing. Other accommodation provided includes staff rooms, workshop and store, research laboratories for staff and post-graduate students and an advanced teaching laboratory. An instrument room, optical cubicle, map room and museum, nitrogen room, dark room and tutorial room are also provided.

Fig. 1. Chemical laboratories at Aberdeen (left) for medical students before 1896; (right) for science students about 1896

Teaching laboratories and lecture rooms are provided with plenum air as well as general air extraction. All research laboratories have high- and low-level extract from fume-cupboards. In the organic and inorganic laboratories, bench extract is also provided throughout. Research laboratories are designed with the view of maximum interconvertibility for use in any of the three branches of chemistry. Services include high-pressure air, and in some rooms vacuum, in addition to the usual gas, water and electricity supplies. Distilled water is piped from a central unit and also hydrogen sulphide. Many of the research laboratories contain, in addition to several sets of wall services, a complete set of services centrally placed at floor-level and accessible by removing a floor panel. All floors in research and teaching laboratories are sloped to drainage points so that water on floors is removed with minimum difficulty. Research laboratories are of several sizes capable of accommodating from one to four research workers.

Chemistry has advanced steadily within the University of Aberdeen, and the present big step forward emphasizes the high esteem in which the profession of chemistry is held. The first chair of chemistry in Scotland was occupied in Aberdeen in 1793 by George French, surgeon and chemist, although some instruction on the subject was given considerably earlier. While on one hand the cultural value of chemistry was acknowledged remarkably early within the Universities of Aberdeen, on the other

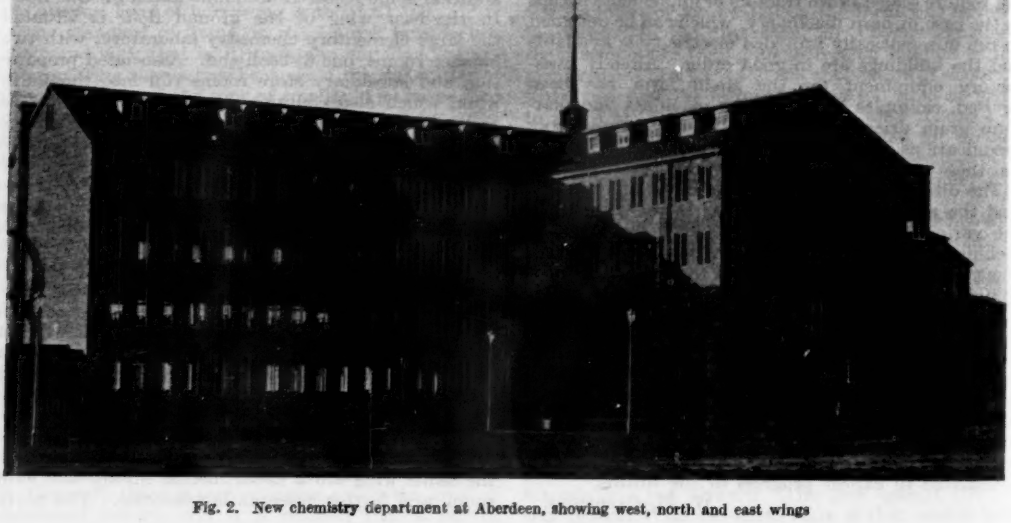

Fig. 2. New chemistry department at Aberdeen, showing west, north and east wings

hand, over all this earlier period no great efforts were spared for research. It was not until Carnelly (1888–90) and Japp (1890–1914) occupied the chair that it was considered particularly necessary for teachers of chemistry to try to extend the boundaries of the subject. Even with the growth of a new attitude, progress in research was not rapid. However, enthusiasm for original investigation was carefully fostered by later occupiers of the chair. There is now a vigorous research school, and the new building reflects the attitude that research as well as teaching is a vital part of any balanced university department. Three photographs are reproduced in this article which indicate the revolution in the provision made for chemistry over the past sixty years. The first photograph shows the chemical laboratory for medical students prior to 1896 and the second the chemical laboratory for science students at about the same time; both are reproduced by kind permission of Prof. A. Findlay, from his book "The Teaching of Chemistry in the Universities of Aberdeen" (Aberdeen University Studies, No. 112). The third photograph is of the west, north and east wings of the chemistry department of 1952. The subject is a forward-looking one where past triumphs are ever likely to be overshadowed by future achievements on a scale still more grand. Nevertheless, there is great interest in looking back and retracing paths, both scientific and personal, trodden by chemists of bygone generations. Such retrospect is bound to emphasize the mounting tempo of science, with all the responsibilities it brings.

THE UNIVERSITY OF CEYLON

By Sir IVOR JENNINGS, Q.C.
Vice-Chancellor

ON October 6, the University of Ceylon moved 851 students, of whom exactly 300 were women, from Colombo to Peradeniya, near Kandy. They included all the students in oriental studies, arts and laws and the senior students in agriculture and veterinary science. The Faculties of Science and Engineering will move when their buildings are ready. The Medical School will remain in Colombo; but it is proposed to establish a second medical school in Peradeniya by 1960.

The 851 students include 27 Buddhist monks, who are housed in a University bungalow pending the erection of a monastery by the University Sangharama and Vihare Trust. The other 824 students are housed in five halls of residence. These halls are built on the principle of one student to each room; but since three halls—housing 490 students—will not be ready until 1953, there are usually two students in each room. The cost of residence is Rs. 630 (£46) per annum, and there are no tuition fees for Ceylonese students. Even so, about one-third of the students are subsidized, the University paying the whole or a part of the residence fee.

The present University Park contains 300 acres; but the land vested and to be vested in the University covers 3,000 acres. It includes a tea estate of 1,100 acres which is being converted under a ten-year plan into a timber estate. It also includes an experimental farm of 650 acres (of which 240 acres are cultivable) which is at present used as a School of Agriculture but will be transferred to the Faculty of Agriculture in 1953. This area of land stretches up the valley of the Mahaweli-Ganga for two miles, enclosing the headquarters of the Government Department of Agriculture and the Royal Botanic Gardens.

For seven years in the fourteenth century Peradeniya was the capital of the Sinhalese monarchy. When the capital was moved down the river to Kandy, Peradeniya became a royal garden. Under British rule a small portion (140 acres) became the Royal Botanic Gardens, while the remainder was put first under coffee and sugar and then under tea and rubber. The land receives both monsoons and therefore about 100 in. of rain a year. This creates a luxuriant tropical vegetation, which supports a remarkable fauna. Twenty-six varieties of birds have been identified from the Lodge, without using binoculars. Some ornamental trees were left by the superintendent of the tea estate; but planting was begun in 1942 and is continuing as areas are taken over under the landscape scheme. The climate is equable, for the buildings are between 1,600 and 1,700 ft. above sea-level.

This magnificent valley, framed by the great Hantane Ridge (4,500 ft.) from which the University draws its water supply, is one of the most beautiful university sites in the world. The layout was planned by Sir Patrick Abercrombie and Mr. Clifford Holliday, while the building plans were drawn by a Sinhalese architect, Mr. Shirley d'Alwis, who died of a heart attack two weeks before the students came into residence. Great care has been taken with the architecture of this central group, ancient Sinhalese motifs, mostly of the Polonnaruwa period (A.D. 1000–1200), being adapted to modern buildings. The long and narrow Senate Building, for example, is raised on granite pillars like the Brazen Palace at Anuradhapura, though the weight is carried by good English steel. The canopy of the University Theatre is supported by carved granite pillars, while the massive doors, made of Ceylon teak, are carved in Embekke style. There is, too, a huge 'moonstone', six feet in diameter, carved out of a solid block of granite in the style of the giant moonstone at Anuradhapura. In the Senate Building, Hilda Obeyesekera Hall and elsewhere much use has been made of lacquer-work carried out by Kandyan craftsmen, who have been at work for the past five or six years. On account of expense, however, most of the architectural detail has been carried out in concrete.

Though Kandy is only four miles away, it has been necessary for the University to organize many of its own services. Water is drawn from the University estates on Hantane; gas will have to be made on the site when the laboratories come into use; electricity is taken in bulk from the hydro-electric scheme and distributed by the University as licensed supplier through three transformer stations; a separate telephone exchange is being established under University control; a University Supply Organization has been established to purchase and distribute supplies through a University shopping centre (not yet erected); an electric laundry is being established; the University owns 135 houses and expects to own another three or four hundred; and a school will have to be provided when the technical staffs of the Faculties of Science and Engineering come into residence. In short, the University Park is much like a small 'company town'.

The residential system was adopted for Ceylon after a controversy which lasted fifteen years, in which much use was made of the Sadler Report on the University of Calcutta in 1919. To the usual advantages of residential education must be added

several derived from local conditions. The climate of Peradeniya is better than that of Colombo, and strenuous games can be played more easily. The great natural beauty and the flora and the fauna both of the University Park and of the Royal Botanic Gardens are of considerable educational value. The heavy concentration on examination qualifications can be diminished by residential education. The authoritarian character of parental control, though in many respects admirable, tends to curb initiative and enterprise, and makes it useful to take undergraduates away from their parents for three or four years. Some attempt can be made, too, to alter the current scale of values, which derives from a combination of caste traditions and Colonial rule.

A VERSATILE FOCUSING SYSTEM FOR VAN DE GRAAFF ACCELERATING TUBES

By P. HOWARD-FLANDERS

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Of the positive-ion accelerating tubes used with high-voltage generators, most have been built with focusing systems which follow the techniques developed by Tuve[1] and many others. In these, use is made of focusing lenses of the type which occur between axially spaced cylindrical electrodes at different potentials.

There is, however, an alternative system of focusing which is very suitable for use in the accelerating tubes of Van de Graaff and other high-voltage machines. This system uses the type of lens which occurs at the aperture in a diaphragm separating two regions of uniform but differing electric field-strength. It is arranged by means of a suitable resistance-potential divider that the electric field is low for a short initial section of the tube and has a uniform high value for the whole remaining length; thus forming a focusing lens at the change of gradient which can be used to bring particles admitted at one end to a focus on the target at the other.

Accelerating tubes are usually constructed with a large number of electrodes at graded potentials, as it is found that tubes of this construction stand up best to use at high voltages[2]. The electrodes are often closely spaced, so that they produce a very nearly uniform field at the tube axis. In this case, it may be assumed that the field is quite uniform, which, of course, greatly simplifies the calculation of particle trajectories, and a simple first-order non-relativistic theory has been worked out for the conditions for focusing particles on to the target.

The focal length of the aperture lens is given by the well-known formula $F = 4V/(E_2 - E_1)$ for a particle accelerated through a potential difference V on passing from a region of field E_1 to a region of field E_2, assuming that the change of gradient occurs within a range of potential small compared with V. This formula has served as the basis for calculating the results which follow. Consider an accelerating tube in which the electric field is E_1 for a distance L_1 and is E_2 for a distance L_2, followed by a field-free target extension tube of length L_3 as shown in the diagram. Let the potentials at the point of injection, at the change of gradient and at the target, be V_0, V_1 and V_2, respectively, measured relative to the potential at which the particles are at rest. Then any particles injected into the tube at a potential V_0 will be brought to a focus at the target if the following condition is fulfilled:

$$\frac{L_2}{L_1}\frac{(3p-1)(p+1)}{p^2} = \frac{4q^2q+1)(q-3)L_2+3(q^2-1)^2L_3}{4q^2L_2+(3q-1)(q+1)L_3}$$

where $p^2 = V_1/V_0$ and $q^2 = V_2/V_1$.

A real inverted image is formed of the cross-section of the beam at the point of entry into the tube, the magnification M being given by

$$M = \frac{(p+1)}{p}\frac{L_2}{L_1}\left(\frac{1}{q+1} + \frac{(3q-1)}{4q^2}\frac{L_3}{L_2}\right).$$

We can now consider the properties of an accelerating tube in which the field is graded in the way described. The appropriate potentials have been calculated for a tube in which the length of the target extension tube is comparable with the length of the accelerating tube ($L_3 = 1{\cdot}04\ L_2$), and for three cases where $L_2/L_1 = 5$, 10, or 25. The way in which V_1/V_0 must vary with change of V_2/V_0 in order to focus the particles on to the target is shown in the diagram. It will be noted that focusing cannot be maintained below a certain threshold value of V_2/V_0, usually in the range 30–100, but that above this voltage V_1/V_0 varies in an almost linear way. Straight lines can be drawn which will lie almost on top of each curve, but which depart slightly near the origin, in the manner shown by the dotted lines. V_1/V_0 can be made to vary with V_2/V_0 so as to follow the appro-

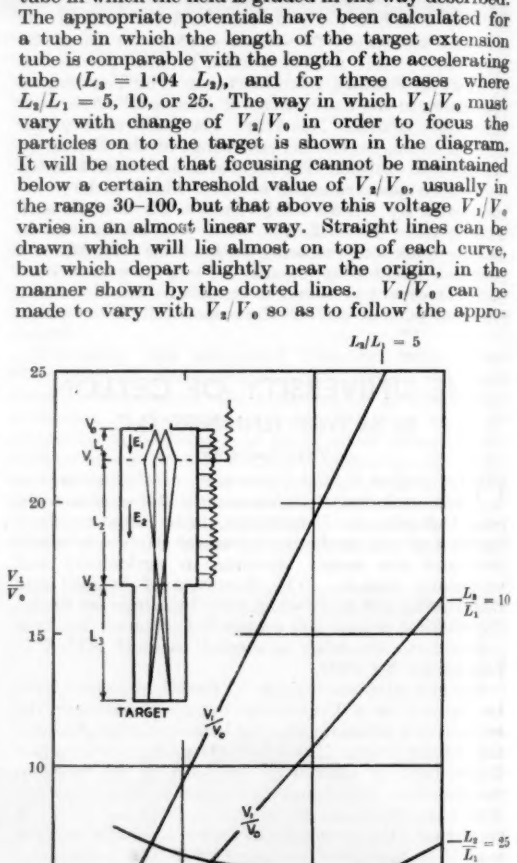

Diagram of an accelerating tube with a resistance chain to control the potential gradient. The values of V_1/V_0 required for focus, together with the corresponding magnification M, are given as a function of V_2/V_0 for an accelerating tube in which $L_3/L_2 = 1{\cdot}04$ and $L_2/L_1 = 5$, 10 or 25

priate straight line by taking V_1 from a suitable resistance chain, terminated at a potential slightly different from zero. It will then be advisable to use a second resistance in parallel with the upper part of the tube, as shown in the diagram, which will serve to grade the potential in the tube between the voltages V_0 and V_1. With a forked resistance chain of this type, V_1/V_0 can be held close to the required value over a wide range of V_2/V_1, so that the tube will be maintained in focus over a correspondingly wide range of operating voltage.

Comparing the curves for different values of L_2/L_1, it will be seen that the longer L_1 is, the wider is the voltage-range over which focusing is maintained. It will also be noted from the second set of curves, which show the magnification, that the longer L_1 is, the lower is the magnification, and hence the smaller is the target spot. The advantages of a long L_1 must, however, be set against the fact that the gradient in L_1 is lower and, for a given total length of accelerating tube, the maximum voltage which the tube will withstand is likely to be reduced by increasing L_1 at the expense of L_2. The choice of the best length L_1 is therefore a compromise, and the best value will depend upon the particular purpose for which the system is to be used.

We can now consider how a machine will behave which uses this focusing system. If particles are injected from an ion source working at, say, 4 kV., and if L_2/L_1 is 10, we can expect the system to be in focus when working at any potential above about 300 kV. There are other useful features of a focusing system of this kind. It will operate with large-diameter electrodes, so that it can be made to accept and focus particles injected at larger angles to the axis than is the case with the focusing system first mentioned. Further, as the current drain to large-diameter electrodes is small, it is not necessary to use any high-voltage focusing power-pack, all potentials being drawn from the resistance-potential divider. This simplifies the construction of the high-voltage terminal and the operation of the machine. It also facilitates the use of a single tube, operated at the appropriate polarity, for accelerating electrons or positive ions.

This focusing system has been tested in a preliminary way on the 2-MeV. pressurized Van de Graaff generator at the Radiotherapeutic Research Unit of the Medical Research Council and is used for accelerating positive ions or electrons as required. Ions are injected into the tube at a potential of about 200 volts into a uniform field E_1 which extends about one-tenth of the distance along the tube to the region where the field increases to the higher value. The full internal diameter of the electrodes in the accelerating tube is maintained without any diaphragm or constriction, so that the change of gradient is spread out axially to some degree. However, good focusing has been obtained over a wide range of voltage and current for both electrons and positive ions. The resistance values in the potential divider are set in advance to the theoretical value and there is no provision for adjustment in use. The resistance-potential divider has proved adequate for controlling the gradient for ion currents three or four times larger than drain through the resistances, indicating that the current to the large-diameter electrodes is very small. The observed magnification has been found to be in rough agreement with that predicted by the theory. The introduction of this focusing system has greatly improved the focus of the beam and has made possible some increase in the maximum currents obtained with this machine. The accelerating tube has been used to carry 350 μamp. of mixed positive ions at 2 MeV. continuously and more than 500 μamp. for short periods.

I am indebted to Mr. T. Wilson, whose formulation of the condition $L_1 = 2V/(E_2 - E_1)$ for the collimation to parallel of a divergent beam of particles injected with small velocities constituted one of the early steps in the development of the general formulæ presented above. [June 20.

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ESTIMATION OF THE 'BOUND FORM' OF NICOTINIC ACID

By Dr. K. K. REDDI

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IT is now well established that in some cereals the nicotinic acid is present to a large extent in a bound form, which is alkali labile[1-5]. Krehl and Strong[6] called this form the precursor of nicotinic acid. The assay methods employed for the estimation of the bound form are essentially microbiological. These microbiological assays do not give a correct estimate of the amount of the bound form, since the various organisms employed for these assays seem to utilize to a certain extent the intact precursor as a source of nicotinic acid. Thus, for example, *Lactobacillus arabinosus* seems to utilize the precursor up to about 45 per cent[3] or to 80 per cent[6], while *Lactobacillus casei* could utilize it to the extent of 10–20 per cent[10]. These considerations must obviously be taken into account in interpreting the results of microbiological assays.

The method I have employed is based on earlier observations that the 'bound form' does not move on paper chromatograms, developed in *n*-butanol – water solvent system or in 60 per cent *n*-propanol, but remains at the origin[11]. Its position can be located by its bluish-white fluorescence under ultra-violet light and by its orange colour when treated with cyanogen bromide and *p*-aminobenzoic acid[11]. In the case of materials containing the coenzymes, it is better to develop the chromatograms in 60 per cent *n*-propanol, since in this solvent system coenzymes I and II have the R_F values 0·26 and 0·15, respectively[11]. The interference with coenzymes that survive the following extraction procedure is eliminated. Thus it is easy to separate quantitatively the bound form from other nicotinyl compounds by developing the chromatograms in a suitable solvent system.

The procedure for the quantitative estimation described below consists in: (1) extraction with acidic methanol, (2) separation of the bound form on the chromatograms, (3) elution with *N* sodium hydroxide and estimation as free nicotinic acid. The values for the amount of the 'bound form' in the samples analysed were expressed in terms of free nicotinic acid.

(1) *Extraction.* 2–5 gm. of the material was extracted by refluxing on a water-bath with 20 ml. acidic methanol (80 ml. methanol + 20 ml. 0·5 *N* hydrochloric acid) for 1 hr., and after cooling the supernatant liquid was decanted. The residue was extracted with 20 ml. acidic methanol in the same

way for 1 hr. and the supernatant liquid was decanted. The residue was again washed twice with 10 ml. acidic methanol each time and the washings were added to the supernatant liquid. The combined supernatant fluids were kept in the ice chest for 30 min. and the bulky precipitate that separated was centrifuged. The clear centrifugate was decanted off, and the residue in the centrifuge tube was washed with 10 ml. acidic methanol each time and centrifuged. The combined centrifugates were evaporated to dryness at 55–60° C. under reduced pressure. The residue was extracted with 4 ml. of distilled water and centrifuged. The clear 'aqueous extract' contained the whole amount of the 'bound form' (see table).

Nicotinic Acid Content (μgm./gm.) as determined by Different Procedures

Material	Total nicotinic acid (*N* NaOH digestion)	'Aqueous extract' from acidic methanol extraction (*N* NaOH digestion)	Present procedure (*N* NaOH elution from paper strips)
Wheat bran	245	253	249
Rice bran	287	307	291
Groundnut (defatted with ether)	276	218	nil
'Gluten Feed 6' (maize bran)	56*	50	nil

* 5 gm. 'Gluten Feed' was extracted with 50 ml. 0·1 *N* hydrochloric acid on a water-bath. An aliquot was digested with *N* sodium hydroxide for 30 min. on a water-bath.

(2) *Separation of the bound form by paper chromatography.* 0·01-ml. spots of the 'aqueous extract' were placed on Whatman No. 1 filter paper and descending chromatograms were run overnight employing *n*-butanol – water as the solvent system. The chromatograms were dried at room temperature. The spots at the origin of the chromatograms were marked with pencil under ultra-violet light and the strips were cut out.

(3) *Elution with N sodium hydroxide.* The filter paper strips (5–10 spots) containing the 'bound form' were transferred to a beaker and 20 ml. *N* sodium hydroxide added. They were worked into fine pulp with a glass rod and digested on a water-bath for 30 min. with frequent stirring. The contents were cooled and centrifuged. The residue was extracted twice with 10 ml. *N* sodium hydroxide each time and centrifuged. The combined centrifugates were adjusted to *p*H 6·8 and the volume was made up to 45 ml.

The estimation of nicotinic acid was done by means of the colour reaction with *p*-aminoacetophenone and cyanogen bromide[12], following the revised procedure of Wang and Kodicek[13].

Nicotinic acid in the 'aqueous extract'. An aliquot was digested with 20 ml. *N* sodium hydroxide for 1 hr. on a water-bath and the nicotinic acid was estimated.

Total nicotinic acid. 1–2 gm. of the material was digested with 50 ml. *N* sodium hydroxide for 1 hr. on a water-bath and the nicotinic acid was estimated.

From the results (see table) it appears that in wheat and rice bran the entire nicotinic acid is present in a bound form, whereas in groundnut about 21 per cent of the total nicotinic acid is present in a form which is not extractable with acidic methanol. The higher values obtained by alkali digestion by Sohonie and Misra[14] in the case of groundnut digested with alkali were attributed either to the presence of a bound form or to some non-specific substance. Since the nicotinic acid extractable by acidic methanol was not recovered at the origin of the chromatograms (see table, col. 3), it appears that no 'bound' nicotinic acid of the type found in wheat or rice bran was present.

In a preparation of 'Gluten Feed' (a proprietary maize-bran product) there was no bound form and the entire nicotinic acid was extracted with acidic methanol. The chromatograms of the aqueous extract adjusted to *p*H 5·2 showed the presence of free nicotinic acid, and added nicotinic acid occupied the same position on the chromatogram as that present in the aqueous extract. It is quite likely that in 'Gluten Feed' the nicotinic acid is present in a free form. The pellagragenic nature of the 'Gluten Feed' could be attributed to the presence of a factor or factors which somehow prevent the utilization of the nicotinic acid by the animal system. These factors are most probably alkali-labile, since the digestion with alkali converts pellagragenic material into a pellagra-preventive foodstuff[15].

I wish to thank the Flour Millers' Association for the supply of wheat and rice bran. [June 27.

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CELL WALL OF *MICROCOCCUS LYSODEIKTICUS* AS THE SUBSTRATE OF LYSOZYME

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THE rapid lysis of intact cells of *Micrococcus lysodeikticus* by egg-white lysozyme has left little doubt that this enzyme radically alters some structure involved in the maintenance of the cell's morphological integrity[1]. Although Boasson[2] claimed that the cell wall of *Micrococcus lysodeikticus* was not destroyed by lysozyme but merely rendered more permeable to cellular contents, recent work[3] with the electron microscope has shown degradation and final destruction of the cell wall by lysozyme.

In view of the foregoing evidence, it seemed worth while studying the action of lysozyme on the bacterial cell wall. *Micrococcus lysodeikticus* and *Sarcina lutea* have been found to be refractory to sonic disintegration[4]; but the procedure reported by Salton and Horne[5] has been successfully used in preparing the cell walls of these organisms.

Cell walls prepared from 24-hr. cultures of *Micrococcus lysodeikticus* gave a stable, milky-white,

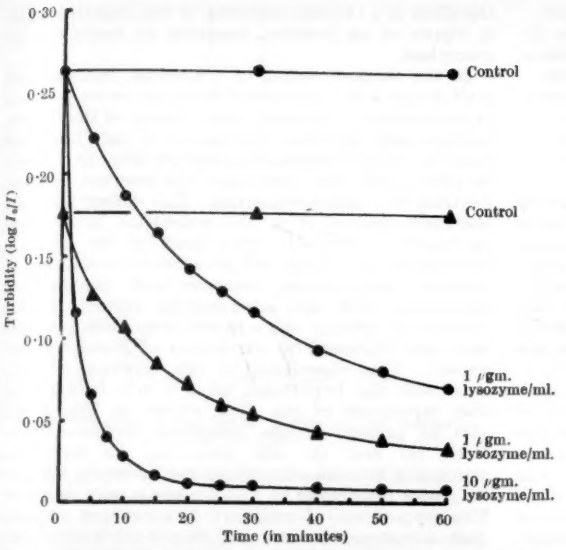
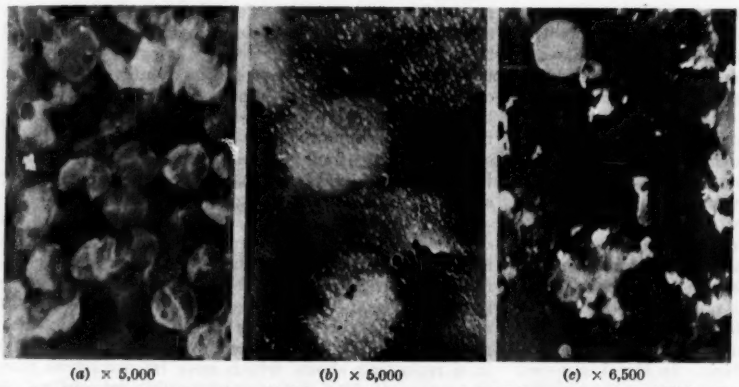


Fig. 1. Progress of dissolution of cell walls of *Micrococcus lysodeikticus* by lysozyme at 37° C., in 0·1 *M* phosphate buffer at *p*H 6·2.
●—●, 150 μgm. dry-weight cell walls/ml.
▲—▲, 100 μgm. dry-weight cell walls/ml.



(*a*) × 5,000 (*b*) × 5,000 (*c*) × 6,500

Fig. 2. (*a*) Untreated suspension of cell walls of *Micrococcus lysodeikticus*. Shadowed at 30° with gold–palladium alloy (60/40 per cent)
(*b*) Cell-wall suspension taken at the point of half-lysis (2½ min. exposure to 10 μgm. lysozyme/ml. at 37° C.). Specimen shadowed at 12°–15° with gold–palladium alloy
(*c*) The concentrated residue remaining after maximum clearing (60 min., 10 μgm. lysozyme/ml. at 37° C.) of the cell-wall suspension. Shadowed as for (*a*)

opalescent suspension. They were suspended in 0·1 *M* phosphate buffer at *p*H 6·2, and the rate of dissolution of the cell walls by lysozyme (Armour Laboratory crystalline, egg-white lysozyme) at 37° C. was followed by measuring the turbidity changes in a Hilger 'Spekker', using yellow-green filters. Lysozyme was dissolved and diluted in 0·9 per cent saline and added to cell-wall suspensions, the dry weights of which were determined by drying aliquots to constant weight at 105° C. The progress of 'lysis' of the cell walls was followed by pipetting 2-ml. aliquots into 0·25-cm. (internal width) cells and reading immediately in the 'Spekker'. Fig. 1 shows the results. A set of curves identical with those in Fig. 1 was obtained when cell walls were suspended in 0·9 per cent saline instead of phosphate buffer.

The rate of dissolution of the cell walls of *Micrococcus lysodeikticus* by lysozyme did not differ significantly over the *p*H range 5·7–7·0 (0·1 *M* phosphate buffers).

In order to determine the nature of the changes lysozyme had effected in the cell-wall structures as seen in the electron microscope, suspensions of the walls of *Micrococcus lysodeikticus* (150 μgm. dry-weight/ml.) were taken at the point of 'half-lysis' (approximately 2½ min. with 10 μgm. lysozyme/ml.) and after maximum clearing (60 min., 10 μgm. lysozyme/ml.). Suspensions were diluted with a large volume of ice-cold distilled water to reduce enzyme action and immediately centrifuged at 10,000 r.p.m. for 20 min. The deposits were re-suspended in distilled water, suitably diluted, and small drops placed on electron-microscope grids and examined in the electron microscope after shadowing specimens with gold–palladium alloy (60/40 per cent). Figs. 2 *a*, *b* and *c* show, respectively, the appearance of untreated cell walls, the half-lysed suspension and the residue (this deposit was re-suspended in two drops of distilled water and therefore represents a considerable degree of concentration of residual material). Partial depolymerization of cell walls, as shown in Fig. 2*b*, is characterized by an apparent reduction in the thickness and rigidity of the wall. The residual material, which accounts for 3–4 per cent of the original turbidity of the cell-wall suspension, consists of cell-wall fragments, a few cell walls which have apparently escaped dissolution and some electron-dense, cytoplasmic debris which probably contaminated the original preparation. These results suggest that there is no evidence for the existence of a lysozyme-resistant framework forming part of the cell wall of this organism, and that lysozyme effects a depolymerization of the whole cell-wall structure, rather than a degradation of a specific part or layer of the wall.

It seems reasonable to conclude that the cell wall of *Micrococcus lysodeikticus* is the insoluble, highly polymerized, mucopolysaccharide substrate of lysozyme. Further investigation of the constitution of the cell wall of *Micrococcus lysodeikticus* and its degradation by lysozyme is proceeding.

I wish to thank Mr. R. W. Horne, of the Cavendish Laboratory, for taking the electron micrographs.

[April 3.

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LETTERS TO THE EDITORS

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Action of Salivary α-Amylase on Amylopectin and Glycogen

Roberts and Whelan[1] have shown that the action of salivary α-amylase on amylose is consistent with the view that the enzyme can hydrolyse any except the terminal α-1 : 4-linkages. This leads to the formation of maltose and maltotriose. Similar studies using the linear maltodextrins[2] have confirmed this hypothesis[3]. We now wish to make a preliminary report of the action of this enzyme on glycogen and amylopectin.

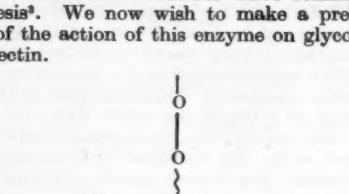

Fig. 1. α-1 : 4-Linkages resistant to α-amylase action O, Glucose unit ; —, α-1 : 4-link ; ⁓, unhydrolysable α-1 : 4-link ; →, α-1 : 6-link

Rabbit liver glycogen (from pregnant does) was exhaustively treated with enzyme purified by the method of Meyer *et al.*[4] and the products were fractionated on a charcoal–'Celite' column[2,5]. Maltose ($4{\cdot}57 \times 10^{-3}$ moles), maltotriose ($2{\cdot}25 \times 10^{-3}$ moles) and dextrins containing α-1 : 6-branch linkages were obtained, but a tetrasaccharide fraction was absent. It was confirmed by paper chromatography that the branched dextrin of lowest molecular weight was a pentasaccharide. The branched dextrins were treated with *R*-enzyme, which hydrolyses the α-1 : 6-linkages[6,7], and the products were again fractionated on charcoal. The following substances were obtained (amounts in 10^{-3} moles) : maltose (1·73), maltotriose (1·73), maltotetraose (1·32), maltopentaose (0·26) and dextrins of higher molecular weight (0·25). These observations are consistent with the following hypothesis of salivary α-amylase action. In Fig. 1 is shown the portion of a ramified polysaccharide in the vicinity of a branch linkage, and it is postulated that each of the three α-1 : 4-links adjacent to the branch link is, in virtue of its position, resistant to hydrolysis by α-amylase.

In the random action of α-amylase, maltose and maltotriose will be liberated from the linear portions of the molecule. Action in the vicinity of the branch linkages must give rise to a mixture of eight branched dextrins if the hypothesis is correct (Fig. 2). It will be seen in the first place that the smallest of these dextrins is a pentasaccharide. This agrees with the observed absence from the α-dextrins of a tetrasaccharide. Secondly, hydrolysis of the α - 1 : 6-linkages by *R*-enzyme will give rise to a mixture of maltose, malto-triose, -tetraose and -pentaose, in agreement with the experimental results. Maltodextrins of greater chain-length than maltopentaose were also liberated by the action of *R*-enzyme (see above). This observation is not, however, at variance with the hypothesis, since it is to be expected that structures of the type shown in Fig. 3 will also be present in the branched polysaccharides. Both (*a*) and (*b*) will give rise to α-dextrins containing two branch-linkages per molecule, whereas the types illustrated in Fig. 2 contain only one link. The hypothesis of resistant 1 : 4-linkages requires that structures 3*a* and 3*b* should each give rise to twelve possible α-dextrins. Three of those derived from the first type (Fig. 3*a*) would, after *R*-enzyme action, produce maltohexaose, which would also result from the debranching of six of the α-dextrins from structure 3*b* ; maltoheptaose would be produced from three of the latter α-dextrins. The measured average chain-length of the mixture of higher dextrins produced by *R*-enzyme action was 6·1, and paper chromatograms confirmed that it consisted of hexa- and hepta-saccharides. It should be noted that, if these inferences can be substantiated, the production of 6- and 7-unit maltodextrins constitutes a proof of *multiple* branching in glycogen. Peat, Whelan and Thomas[8] have already reported evidence of such branching in waxy maize starch.

The information given above may be used to determine the average length of the repeating chains in the branched polysaccharides. A knowledge is required of the difference in the number of molecules in the α-dextrin sample before and after *R*-enzyme action. Thus, in the case of glycogen, calculation gives a value of 12·5 as the number of glucose units in a repeating chain, which may be compared with the value of 13·6 determined in this laboratory by periodate oxidation of the same glycogen.

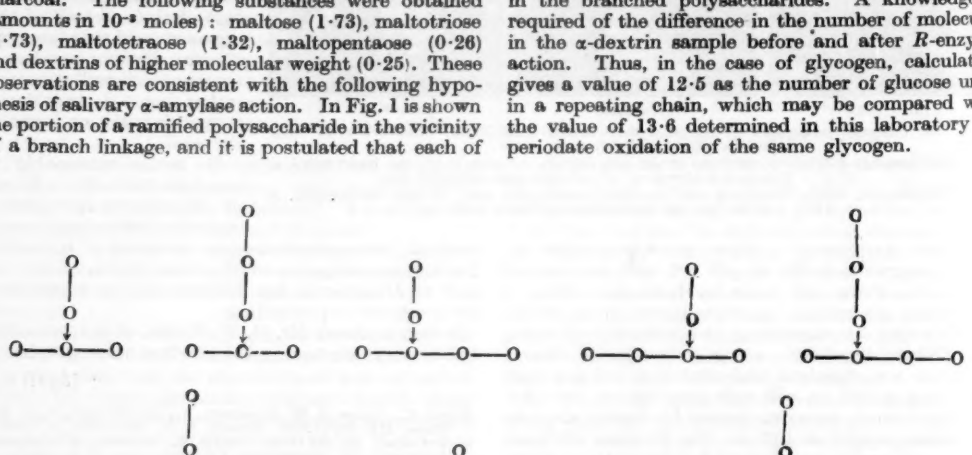

Fig. 2. α-Limit dextrins from amylopectin and glycogen. (Symbols as in Fig. 1)

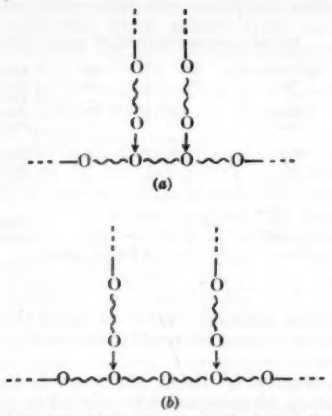

Fig. 3. Structures giving rise to doubly branched α-dextrins. (Symbols as in Fig. 1)

Mention must be made of the presence of fructose in these polysaccharides. As reported recently[9], fructose, in the form of maltulose, has been isolated from rabbit liver glycogen after α-amylase action. In addition, fructose has now been detected in the maltotriose and all other α-dextrin fractions arising from this glycogen. This is also true of waxy maize starch[10]. These findings do not, however, influence the above argument with respect to α-amylase action.

We are indebted to Prof. S. Peat for his continued interest in this work, and to Prof. F. Rogers Brambell for the supply of the rabbit livers.

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Cysteic Acid Transaminase

It has previously been reported by Cohen[1] that enzyme preparations catalysing the reactions:

(1) Alanine + α-ketoglutarate ⇌ glutamate + pyruvate;

(2) Aspartate + α-ketoglutarate ⇌ glutamate + oxalo acetate;

are also capable of catalysing:

(3) Cysteic acid + α-ketoglutarate ⇌ glutamate + sulphopyruvate.

(In a succeeding paper it will be shown that reaction (3) is reversible, which has hitherto not been proved.)

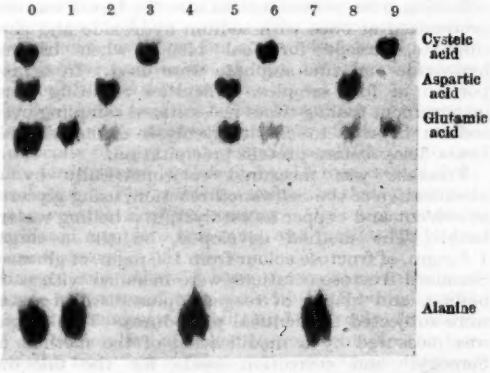
Furthermore, Green *et al.*[2] have shown that (1) and (2) are catalysed by means of two different enzymes, alanine and aspartic acid transaminase.

In experiments reported here, strong evidence is given for the existence of a special enzyme, cysteic acid transaminase, which catalyses reaction (3).

The enzyme is prepared by extraction of acetone-dried ox hearts with water. The liquid is pressed through a linen cloth, and the active material is precipitated with ammonium sulphate at 80 per cent saturation. The precipitate is filtered off and suspended in water and dialysed in a 'Cellophane' tube for 24 hr. The undissolved residue is centrifuged off and discarded. Then the solution is heated for five minutes at 60° C. The heat-coagulated protein is centrifuged off, and the clear supernatant liquid which contains the whole activity is subjected to fractionation with ammonium sulphate. By stepwise increase of the ammonium sulphate concentration, three fractions, *T*(0–50), *T*(50–65), *T*(65–80), are obtained; the numbers in brackets denote the concentration limits, expressed as percentage of saturation, between which the fractions are precipitated. Each of the fractions is examined with regard to its ability to catalyse the three above-mentioned reactions.

The technique adopted in this investigation consisted in incubating the amino-acids together with α-ketoglutaric acid in the presence of the enzyme fractions at 30° C. and *p*H 7·5. After a suitable lapse of time (10 min. in the present experiments), 0·1 ml. of 75 per cent phenol–water mixture is added for each 1 ml. of reaction mixture in order to arrest the reaction. The time of incubation is adjusted so that the relationship between time and the degree of reaction can be considered as linear with good approximation for all of the reactions.

The glutamic acid formed from the ketoglutarate by transamination was separated on filter paper by unidimensional chromatography using 75 per cent phenol as the solvent. In the photograph the qualitative results of a typical experiment are shown. Experimental conditions: 0·5 ml. of 0·1 *M* ketoglutaric acid and 0·5 ml. 0·1 *M* amino-acid solution are incubated for 10 min. with 0·5 ml. enzyme solution, *p*H 7·5, phosphate 1/15 molar, temperature 30° C.



Phenol/water chromatogram showing the formation of glutamic acid from α-ketoglutarate and L-alanine (1), L-aspartic acid (2), L-cysteic acid (3) in the presence of enzyme fraction *T*(0–50); α-ketoglutarate and L-alanine (4), L-aspartic acid (5), L-cysteic acid (6) in the presence of *T*(50–65) and from α-ketoglutaric acid and L-alanine (7), aspartic acid (8) and L-cysteic acid (9) in the presence of fraction *T*(65–80). For comparison, a mixture of cysteic acid, aspartic acid, glutamic acid and alanine is run on the same paper (0)

The reaction is arrested by adding 0·15 ml. 75 per cent phenol–water mixture. For analysis 4 µl. of each mixture is used. The chromatogram is developed with 75 per cent phenol – water mixture on Whatman No. 1 paper. After drying for 1 hr. in an oven at 80° C., the paper is sprayed with 0·1 per cent ninhydrin in butanol. After drying in an air current at room temperature for 5 hr., the chromatogram is photographed.

It can be seen from the chromatogram that (1) is catalysed by T(0–50) but not by T(50–65), as opposed to (3) which is catalysed by T(50–65) as well as by T(65–80). Hence alanine transaminase is not identical with the enzyme which catalyses (3). Furthermore, judging from the intensities of the glutamic acid spots, T(50–65) is more effective for (2) than for reaction (3), whereas the opposite holds for T(65–80). These results are consistent with quantitative results which will be published in due course.

Thus one can conclude that an enzyme, cysteic acid transaminase, exists, which is different from alanine transaminase and aspartic acid transaminase.

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Fœtal Fructose in Various Mammals

Fructose has been reported to occur in the fœtal fluids of a variety of animals, and it has been implied that this sugar is present generally in mammalian fœtuses[1]. However, the earlier claim that fructose occurs in the human fœtus[2] has been refuted[3]. The problem has been re-investigated here during a comparative study of carbohydrate metabolism and related disease problems in the new-born.

Mixed blood samples were obtained mainly from the umbilical cord, or, in the case of the carnivores, from throat blood after decapitation, at birth. Sheep and rodent samples were from the cord and throat blood respectively of near-term fœtuses. After collection over potassium oxalate, the blood was deproteinized at once with sodium hydroxide and zinc sulphate, except for foal blood, when barium hydroxide and zinc sulphate were used. In a proportion of foal samples, difficulties resulting from inconvenient foaling times necessitated sampling over sodium fluoride to check glycolysis during several hours delay before protein precipitation.

Fructose was measured colorimetrically by a modification of the Seliwanoff reaction, using glycerol as solvent and copper as catalyst, in a boiling water-bath. The method developed, on the average, 1·5 mgm. of fructose colour from 150 mgm. of glucose. Standard fructose solutions were included with each boiling, and blanks of reagents plus distilled water were subjected to identical procedures. Total sugar was measured by a modification of the method of Somogyi[4] and correction made for the unequal reducing powers of fructose and glucose. Both methods, as employed here, had a standard deviation of 1 mgm. per cent on 20 similar samples.

The findings are shown in the accompanying table. The classification into orders, although not strictly exact, aids description in the text.

Order	Animal	No. of pregnancies	No. of young	Blood fructose
Ungulata	Horse	20	20	Positive in all
	Pig	12	60	Positive in all
	Ox	1	1	Positive
	Sheep	8	11	Positive in all
	Goat	1	1	Positive
Carnivora	Dog	1	4	Negative in all
	Cat	2	5	Negative in all
	Ferret	1	3	Negative in all
Rodentia	Guinea pig	5	9	Negative in all
	Rabbit	2	11	Negative in all
	Rat	1	Pooled blood from 8	Negative

In addition, fructose was not found in the amniotic fluid of the hen's egg after eight, nine and eleven days incubation.

Actual fructose-levels in blood are not given for the ungulates, as these must be related to parturition and other factors; but they were of the order as those previously reported for the sheep and, with few exceptions, fell between 25 and 130 mgm. per cent.

Slight fructose values which are obtained in the non-ungulate group are difficult to interpret, because the interfering colour from glucose and other chromogens is slightly variable as, also, is the blank colour. From the fact that this colour never exceeded an equivalent as fructose of 3 mgm. per cent above that calculated to be present from glucose, and was frequently much less, fructose has been assumed to be absent, or present only in such trace amounts as might exist in adult blood.

These results suggest that the presence of substantial quantities of fructose in the fœtal blood of land mammals, at or near term, is peculiar to ungulates.

I have had much kind assistance in this work, which will be acknowledged when a more detailed account is presented.

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Activation of the Fluorescence of Chlorophyll Solutions

Chlorophyll dissolved in pure dry hydrocarbons is (practically) non-fluorescent[1–3]. The addition of traces of water, alcohols or amines to solutions of chlorophyll restores their fluorescent intensity to that observed in solvents such as methanol, ether, etc. It was demonstrated by Livingston, Watson and McArdle[1] that this increase in the fluorescent yield is the result of the formation of an addition compound between a molecule of chlorophyll and one of the 'activator'. These authors postulated that the addition compound was formed by the establishment of hydrogen bonds between labile hydrogens of the activator and the keto oxygens of ring V [4] of the chlorophyll molecule. Afterwards, Evstigneev, Gavriola and Krasnovskii[3] presented evidence sup-

porting the view that the activator adds to the central magnesium atom rather than to ring V. They claimed that the fluorescence of pheophytin is as intense in dry as it is in wet toluene, but that the fluorescence of toluene solutions of the magnesium complex of phthalocyanine is increased by the addition of water.

These results[3] with pheophytin solutions have been fully confirmed in our laboratory. However, the conclusions in regard to the phthalocyanines appear to be in error. A 'solution', prepared by mixing dry toluene with an ethereal solution of the magnesium complex of phthalocyanine and then pumping off the ether, is colloidal in nature. The optical density of such a preparation decreases rapidly with time, and if allowed to stand for a few days the blue pigment settles to the bottom, leaving a clear supernatant liquid. In spite of their misinterpretation of the experiments on phthalocyanine preparations, their contention that the activator molecule becomes attached to the magnesium atom appears to be correct.

The equilibrium constant, K, for the formation of the addition compound can be determined from measurements of either the absorption coefficients or the intensity of fluorescence of the solutions. Using quinoline as the activator and chlorophyll *a* as the pigment, identical values for K, of $1{\cdot}33 \times 10^4$ moles/litre, were obtained from measurements of the fluorescent intensity and of the absorption coefficients. From measurements of the changes in the absorption coefficients, it has been shown that magnesium, zinc- or calcium-complexed mesoporphyrin dimethyl ester, magnesium-complexed tetraphenyl chlorin[5], and zinc- or calcium-substituted chlorophyll form addition compounds with alcohols and organic bases. The stability constants of some of these compounds are listed in the accompanying table.

VALUES OF THE STABILITY CONSTANTS OF THE PIGMENT-SOLVENT ADDITION COMPOUNDS

Activator	Pigment			
	Mg-Porph.	Zn-Porph.	Mg-Chph.	Zn-Chph.
Aniline	41		46	
Benzyl alcohol	1,120		2,900	
Quinoline	8,300	1,800	13,300	15,200
Heptylamine	110,000		160,000	

Since the uncomplexed (that is, metal-free) forms of these pigments do not show any change in absorption spectra or in fluorescent intensity when alcohols, etc., are added to their solutions in dry hydrocarbons, presumably they do not form addition compounds of this type.

The evidence in support of the hypothesis that the 'activator' molecules add to the metal ion of the pigment may be summarized as follows. (1) Only the metal-complexed pigments form such compounds; the corresponding compounds containing imide hydrogens do not react in this way. (2) The stabilities of the addition compounds of chlorophylls, chlorins and porphyrins are all of the same order of magnitude. (3) All the known activators are generalized bases (that is, nucleophyllic reagents), and this seems to be the only characteristic which they have in common. (4) Allomerized as well as native chlorophyll[1] shows the effect, although presumably the former molecule cannot undergo a keto-enol tautomerism on ring V[4].

It is noteworthy that, of the pigments investigated, only the magnesium-chlorophylls exhibit a marked change in fluorescent yield accompanying the formation of the addition compound. At room temperature the fluorescent yields of the addition compounds of native chlorophylls *a* and *b* are at least twenty-five-fold greater than the yields of the same pigments in base-free solvents. Under similar conditions, zinc-chlorophyll *a* shows about a 20 per cent increase in fluorescent yield. There is no detectable change in the fluorescent yields of the metal-complexed porphyrin or tetraphenyl chlorin.

In dry benzene, the Soret band of the absorption spectrum of mesoporphyrin appears as two maxima of equal height, situated at 4060 A. and 4160 A. The addition compounds of this pigment with methanol, benzyl alcohol, aniline, heptylamine and quinoline exhibit the usual single narrow absorption peaks, at 4100, 4110, 4120, 4130 and 4130, respectively. None of the other pigments exhibits such splitting of their principal absorption bands.

The detailed results upon which this note is based will be published elsewhere. The experimental work was made possible by the support of the U.S. Office of Naval Research (Project 059, 028, Contract N6, ori 212, T.O. I).

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Histochemical Differentiation of *cis-trans* 1-2 Glycols

SINCE McManus[1] introduced his periodic acid technique for histochemical localization of the 1-2 glycol linkage, the field has been well investigated. Other techniques have been devised, utilizing both periodic acid[2] and lead tetraacetate[3–5], to split the carbon–carbon single bond of the glycol to produce leucofuchsin-demonstrable aldehyde radicals. In all these studies, however, little attention was paid to the linkage itself but rather to the parent compound. The present investigation was undertaken to study the *cis-trans* isomerism of the 1-2 glycol linkage during this oxidative process.

The periodic acid – Schiff technique, as now generally accepted[6], consists of oxidation of tissue sections in aqueous 0·5 per cent periodic acid for 5 min. at room temperature, followed by 15 min. staining in leucofuchsin. The stained sections are then processed in the routine Feulgen manner. Glycol cleavage is considered complete in 5 min., and further oxidation is unnecessary.

Criegee and others[7,8] have shown that there is a definite sequence of reaction with both periodic acid and lead tetraacetate in splitting 1-2 glycols. Initially, the *cis* isomers are attacked in preference to the less accessible *trans* forms. Then, as the reaction continues, the *trans* isomers are attacked to complete the cleavage of all the glycol forms.

To study this aspect of glycol oxidation histochemically, two series of experiments were prepared, one utilizing gelatin blocks and the other using tissue sections. The gelatin blocks were prepared after the

manner of Lessler[9] and were impregnated individually with isomers of cyclohexane glycols. The tissue sections were routinely prepared by the paraffin method from formalin-fixed blocks of rabbit, rat and human intestine. These preparations were simultaneously submitted to timed oxidations in 0·5 per cent periodic acid. Following oxidation, they were processed by the McManus method. The amount of violet coloration produced by the leucofuchsin was then studied as to intensity, and, in the case of the tissue sections, location.

Cleavage of the *cis* cyclohexane isomers in the gelatin blocks was apparent after 10 sec. oxidation, and the reaction appeared complete after 1 min. The *trans* isomers, reacting more slowly, did not show positive coloration until after 30 sec. oxidation and continued to develop colour until 2 min. after oxidation.

Tissue sections appeared to give a 'diphasic' colour development which could be correlated with the gelatin block findings. After 1 min. of oxidation, leucofuchsin-positive material could be detected on the periphery of the mucin content of goblet cells and in the cuticular margin of the columnar cells. The colour intensified with further oxidation, reaching a maximum in about 3 min. After 2 min. of oxidation, the centre of the mucin mass of the goblet cells also began to show coloration, which increased in intensity with further oxidation, reaching its maximum after 5 min. There also appeared to be a definite variation in the cleavage-rate in the goblet cells at the base of the villi and those toward the lumen. The mucin of the deeper cells gave a positive leucofuchsin reaction much sooner than that of the outer cells, in many cases showing almost complete coloration after only 3 min. of oxidation. Conversely, it often took 6–7 min. of oxidation to demonstrate completely the mucin of the outer goblet cells.

This differential glycol cleavage is more noticeable when uncatalysed lead tetraacetate[4] is used as the oxidizing reagent. The oxidation proceeds more slowly and is not complete until after 30 min. The *cis* isomer cleavage is not completed for almost 15 min., while the *trans* isomers are not initially attacked until after at least 10 min., of oxidation.

These experiments seem to indicate that it is at least empirically possible to differentiate histochemically the *cis* isomers of the 1-2 glycol linkage from the *trans* forms by the rate of cleavage during periodic acid oxidation. Those glycols which can be demonstrated after 2 min. of periodic acid oxidation would appear to be of the *cis* type, while those appearing after that time are probably mainly of the *trans* form. If this assumption is true, it will be a great help in accurately determining the exact nature of the compounds containing 1-2 glycol linkages in various tissue components.

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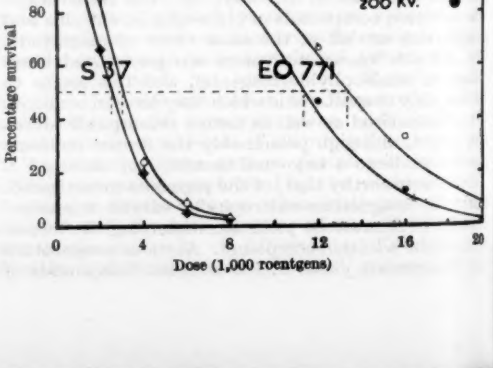
Relative Biological Effectiveness of Betatron and Conventional X-Radiation on the Regression of Mouse Tumours

The development of more-powerful sources of X-radiation has made possible the investigation of the biological effectiveness of a variety of ionizing radiations. *In vitro* experiments have suggested that radiations of higher specific ionization have a greater lethal effect on mouse tumours[1]. We have compared the relative biological effectiveness, on two types of mouse tumours, of 200-kV. radiations from a conventional X-ray machine with 23·5-MeV. radiations from the University of Saskatchewan betatron.

The tumours used were mammary gland adenocarcinoma *EO*771 and sarcoma 37 and were carried in *C*57 × *C*3*H* hybrid mice. The transplants were made into the right axillary region of healthy hosts by the trocar method. For radiation, the mice were placed in lead containers with the tumour projecting, and irradiation was limited to the tumour. The sarcoma 37 was radiosensitive and the radiation was given in a single dose. Adenocarcinoma *EO*771 was relatively insensitive, and to attain a sufficiently high dosage the dose was fractionated, 4,000 r. being given weekly until the full dosage was reached. Tumours had attained a volume of 100 mm.^{3} when irradiated. Lethal regression was judged both by immediate decrease in size and finally by the disappearance of the tumour within three weeks of radiation. The results are shown in the accompanying graph.

Using the method of Bliss[2], the sigmoid survival curves were converted to straight lines and the mean lethal doses were determined. These were 13,500 ± 700 r., and 11,400 ± 700 r. for betatron and 200-kV. radiation respectively with adenocarcinoma *EO*771; 3,100 ± 200 r., and 2,500 ± 200 r. for betatron and 200-kV. radiation with sarcoma 37. This gave values for the ratio of effectiveness of the two radiations of 0·87 ± 0·05 with tumour *EO*771, 0·81 ± 0·08 for *S*37. It is of interest that the ratios obtained agreed closely with that found with these same tumours, at lower dosage-levels of these radiations, as judged by decrease in volume of the tumour[3], and were of the same order as the ratio obtained for the relative lethal effect on yeast[4]. In contrast, the relative effectiveness of the betatron radiation in causing leucopænia in mice[5] was 0·6, which suggested that the effective dose received by the mouse tumour per unit tolerance dose was higher for the betatron radiation than for the conventional 200-kV. X-radiation. The mean specific ionization for betatron radiation is 6·2 com-



pared to 55 for 200-kV. radiation[6], or a ten-fold difference in specific ionization. Sugiura[1], comparing gamma radiation with 200-kV. radiation, obtained a ratio of biological effectiveness of 0·67 for a seven-fold difference in specific ionization.

The results of this investigation will be published in detail elsewhere[7]. We are indebted to the National Cancer Institute of Canada and the Saskatchewan Cancer Society for generous support of our studies.

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New Hydroxamic Acids as Antitubercular Agents

Previously, one of us suggested using salicylhydroxamic acid as an antitubercular agent[1]. The substance was subjected to clinical examination by another of us (S. H.) and showed promising results in fifteen cases of pulmonary tuberculosis. The substance was well tolerated by the patients, when large doses of 10–20 gm./day were administered.

This led one of us (T. U.) to look for more potent derivatives of salicylhydroxamic acid. Eventually, a number of derivatives of it were prepared. Some of them, for example, 3-bromosalicylhydroxamic acid ('*T* 40'), 2-hydroxy-3-methyl-benzhydroxamic acid (2,3-cresotinohydroxamic acid, '*T* 95'), 2-hydroxynaphtho-3-hydroxamic acid ('*T* 106'), 2-hydroxyquinoline-7-hydroxamic acid ('*T* 139'), proved to be more potent *in vitro* than salicylhydroxamic acid. All these substances are new to the literature.

5-Bromosalicylhydroxamic acid (m.p. 232°) was prepared by direct bromination of salicylhydroxamic acid in acetic acid medium and purified by crystallizing from alcohol[2]. 2,3-Cresotinohydroxamic acid (m.p. 148°–150° decomp.), 2-hydroxynaphtho-3-hydroxamic acid (m.p. 191°–192° decomp.) and 8-hydroxyquinoline-7-hydroxamic acid (m.p. 208°–209° decomp.) were prepared in the conventional way by the action of hydroxylamine on methyl esters of 3-cresotic, 2-hydroxy-3-naphthoic and 8-hydroxyquinoline-7-carboxylic acids respectively. Details of their preparation will be reported elsewhere[3].

The bacteriostatic concentration *in vitro* of these substances against saprophytic mycobacteria was found to be:

Table 1

Sodium salts of	*T* 40	*T* 95	*T* 106	*T* 139
	15–30	15–75	8–16	2–4 mgm. per 100 ml.

Their toxicity to rats (lethal doses expressed in gm. per kgm. body-weight) is shown in Table 2.

Table 2. Lethal doses (gm./kgm. body-weight)

Substance	*per os*	Subcutaneous	Intravenous
T 40	*c.* 3·5	0·8	0·12
T 95	*c.* 3·0	0·6	0·15
T 106	*c.* 2·0	(insoluble in water)	
T 139	*c.* 2·0	0·3	0·03

Besides the toxicity control, the products have been examined as to their pharmacological activities on different organs. The experiments showed only a very weak action upon the animal organisms.

Experiments *in vivo* with '*T* 40' were carried out by using guinea pigs (*c.* 500 gm.) inoculated intraperitoneally with 0·1 mgm. of *Mycobacterium tuberculosis* ($H_{37}Rv$ strain). Administration of the drug started on the eighth day after inoculation and lasted for forty-two days. Thirty-five days later the animals were killed and the extent of tuberculous involvement was examined. The results are shown in Table 3.

Table 3

Substance	No. of animals	Daily dose (mgm. per animal)	Administration	Mortality	Average tuberc. index	Average survival time
'*T* 40'	20	10	subcut.	4 (20%)	65	80·2
Streptomycin	20	10	„	2 (10%)	57	84·4
Control	20	—	—	18 (90%)	100	47·2

Similar results were obtained with '*T* 106', the mortality being only slightly greater than that of the animals treated with streptomycin. The results with '*T* 95' were less favourable[4].

The action of bromosalicylhydroxamic acid on human tuberculosis was then investigated clinically. 1 gm. a day was administered in twenty-five cases for periods of 25–102 days; a total of 25–100 gm. was administered in each case. The drug was well tolerated even if the dose was increased to 2 gm. Particularly interesting were nine cases of tubercular meningitis, which did not appear to be influenced by streptomycin. The additional administration of '*T* 40' in most of these cases produced a considerable improvement. The results are shown in Table 4.

Table 4

	After administration of '*T* 40'; number of cases				
	Very great improvement	Considerable improvement	Marked improvement	No improvement	Worsening
Tubercular meningitis unsuccessfully treated with streptomycin	1	4	2	1	1
Miliary tuberculosis		1	2		
Infiltrative pulmonary tuberculosis		2	2	1	2
Chronic cavernous tuberculosis			1		3
Pleurisy with effusion and diffuse tuberculosis	1				

Of twenty patients showing radiologically tuberculous lesions in the lungs, nine showed a pronounced improvement of the radiological picture (two of them very considerable improvement), eight showed no improvement, and three became worse.

Some of the patients resistant to '*T* 40' have been treated with streptomycin; no improvement followed[5].

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Survival of the Perfused Cat's Brain in the Absence of Glucose

In recent experiments in which the cat's brain was perfused through the isolated cerebral circulation with glucose-free 'simplified blood', brain functions were maintained for well over an hour if the rate of flow of blood was kept high. In previous perfusion experiments with glucose-free blood, the vascular resistance in the brain usually rose, reducing the rate of flow of blood considerably, with consequent loss of physiological activity of the brain and reduction of its oxygen consumption after 10–15 min. of glucose-free perfusion. When glucose was added afterwards to the blood, it was not taken up by the brain unless fresh liver extracts were also added[1].

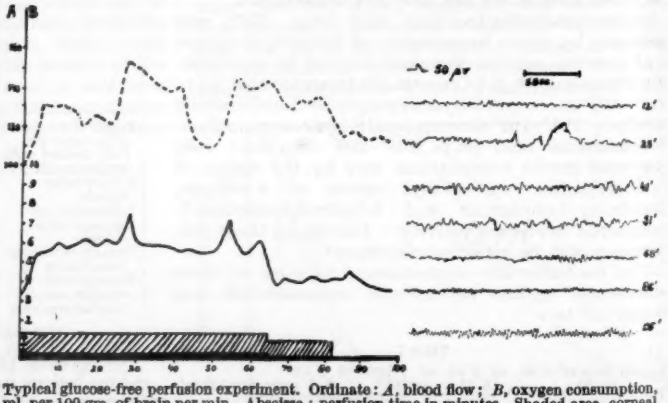
In the present experiments the technique of isolating the brain circulation and the method of perfusion were similar to that described previously[2]. Special care was taken to avoid contamination of the perfusion blood with the cat's systemic blood. Thiocyanate injected into the cat's circulation did not enter the perfusion blood. In some experiments all the extracranial soft tissue was removed from the head. These experiments gave results identical with those in which this precaution was not taken. Brain samples weighing 100–200 mgm. were excised during perfusion for analysis.

The bovine blood corpuscles used for perfusion were washed with 30–60 volumes of Ringer's solution containing penicillin, and 35 parts were suspended in 65 parts of a medium containing 7 per cent bovine serum albumin (Armour and Co.), 0·9 per cent sodium chloride, 0·044 per cent potassium chloride, 0·19 per cent sodium bicarbonate, 0·037 per cent calcium chloride, 0·038 per cent magnesium sulphate, and 0·021 per cent potassium dihydrogen phosphate. This 'simplified blood' was saturated with 5 per cent carbon dioxide in 95 per cent oxygen. A flow of 100–250 ml. per min. of blood for 100 gm. of brain was maintained.

Brain activity. A typical electro-corticogram is reproduced. In some experiments rhythmical electrical activity was still discernible after 90 min. of perfusion. The corneal reflex, respiration and vasomotor activity persisted for 60–100 min. The response to afferent stimulation of the sciatic nerve could be recorded from the cortex for a similar period of time. Addition of 'Metrazol' to the perfusion blood 40 min. after the start of perfusion caused convulsions which could be repeated; 3 mgm. of 'Nembutal' added to the perfusion blood at its entrance to the brain after 50–60 min. of perfusion extinguished the electro-corticogram within a few seconds and the corneal reflex and respiration shortly afterwards.

Oxygen consumption. During the present glucose-free perfusion experiments, oxygen consumption was very nearly as high as in other experiments in which glucose was present in the 'simplified blood'[3]. The usual rates were 5–7 ml. oxygen per 100 gm. brain per min. The total amount of oxygen consumed by the brain during the first hour of glucose-free perfusion exceeded by several times the amount necessary for the oxidation of the carbohydrates available at the start of the perfusion in the brain. During metrazol convulsions, even when 'Metrazol' was administered 50–60 min. after the start of glucose-free perfusion, the rate of oxygen consumption increased two- to three-fold. 'Nembutal' in a concentration of 3 mgm. in 100 ml. blood decreased the oxygen consumption only slightly. The respiratory quotient of the brain was 1·00 at the outset and decreased as perfusion progressed. Values as low as 0·50 were found frequently, even though the oxygen consumption remained high.

The glucose content of the brain was usually very low or dropped to zero after 10 min. of perfusion. In most experiments a small amount of glycogen remained in the brain throughout. A slight increase of glycogen in the brain was also found in some cases towards the end of the perfusion period. The concentration of lactic acid in the brain decreased gradually during perfusion, contrasting in this respect with similar experiments in which the perfusion blood contained glucose[3]. The potassium concentration in the brain decreased gradually and the sodium concentration increased during perfusion. Thus in some cases during prolonged perfusion experiments while



Typical glucose-free perfusion experiment. Ordinate: *A*, blood flow; *B*, oxygen consumption, ml. per 100 gm. of brain per min. Abscissa: perfusion time in minutes. Shaded area, corneal reflex; heavy line on abscissa, duration of natural respiration. Full line, oxygen consumption; broken line, rate of flow of blood. The figures next to the electrocorticograms show perfusion times in minutes

No. of experiments	Perfusion time (min.)	ml. per 100 gm. brain per min.		R.Q.	mgm. in brain			Oxygen consumed by 100 gm. brain in 1 hr. (ml.)	Oxygen not accounted for by carbohydrates (ml.)	Electrocorticogram	Cortical response to afferent stimulation	Respiration	Corneal reflex
		Blood flow	Oxygen consumed		Glucose	Glycogen	Lactic acid						
9	20	165 (115–215)	6·4 (4·8–8·0)	0·75 (0·54–0·90)	4 (0–10)	18 (0–42)	148 (80–216)			+	+	+	+
9	40	170 (135–220)	5·8 (3·4–7·5)	0·60 (0·34–0·89)	3 (0–6)	18 (6–37)	83 (25–133)			+	+	+	+
8	60	163 (90–220)	5·2 (3·2–6·5)	0·72 (0·51–1·05)	3 (0–10)	20 (14–30)	65 (16–115)	407	325	+	+	+	+
4	80	142 (115–190)	4·1 (2·7–5·5)	—	3 (0–7)	27 (20–34)	69 (68–70)			+	+	+	+
2	100	127 (120–135)	3·7 (3·2–4·2)	0·89	7 (0–15)	37 (34–42)	85 (81–90)			+		+	+

The figures in brackets show the lowest and highest values found.

the brain was still active, the concentration of sodium in the brain was higher than that of the potassium.

The non-protein nitrogen in the blood and in the brain increased only very slightly during perfusion.

The observations, which are summarized in the accompanying table, show that the brain continues to function in the absence of glucose, if the rate of flow of blood is high. Presumably substances other than glucose or glycogen are oxidized, while oxygen consumption is maintained at about the same rate as in the presence of glucose. Under these conditions the brain maintains for well over an hour rhythmic electric activity and the ability to respond to chemical or afferent stimulation.

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Necessity of Boron for *Nostoc muscorum*

There are very few reports on the necessity of boron for the growth of lower plants. Koffler *et al.*[1] found that borax increased the penicillin yields of submerged corn-steep cultures of *Penicillium* as well as cultures of *Penicillium* in synthetic medium. No definite requirement by algæ for boron has yet been shown[2].

I wish to report that *Nostoc muscorum* grown in Corning (boron-free) flasks in media free from boron requires boron. The boron-free cultures showed a relatively small reduction in cell count and a chlorosis which started slowly during the third week; they became completely white by the end of eight weeks. The reduction in cell count for an eight-week growth period was 39 per cent for cultures grown at a light intensity of 100 ft.-c. and at a temperature of 32–34° C. Since appreciable boron is transferred through the inoculum, it was found best to use an inoculum which itself was boron-free. The boron-deficiency chlorosis was corrected by the addition of boron. One fairly old boron-deficient culture had become acidic and also had to be made alkaline in order to transform the culture into one with a normal green colour. A detailed study of *p*H and boron-deficiency failed to establish any relationship between the deficiency and a trend toward higher hydrogen-ion concentration.

Cultures grown in Corning flasks with boron added or in 'Pyrex' flasks with or without boron added did not show similar chlorosis. The optimum boron concentration appeared to be about 0·1 p.p.m. Concentrations greater than 1 p.p.m. were toxic, as indicated by a yellowing and a reduced growth. There was very little or no growth at 100 p.p.m. and more.

The cultures of *Nostoc muscorum* were bacteria-free pure cultures, and were originally obtained from Dr. Folke Skoog and Dr. G. C. Gerloff, of the University of Wisconsin. They were grown according to the method of Chu (formula number 10)[3].

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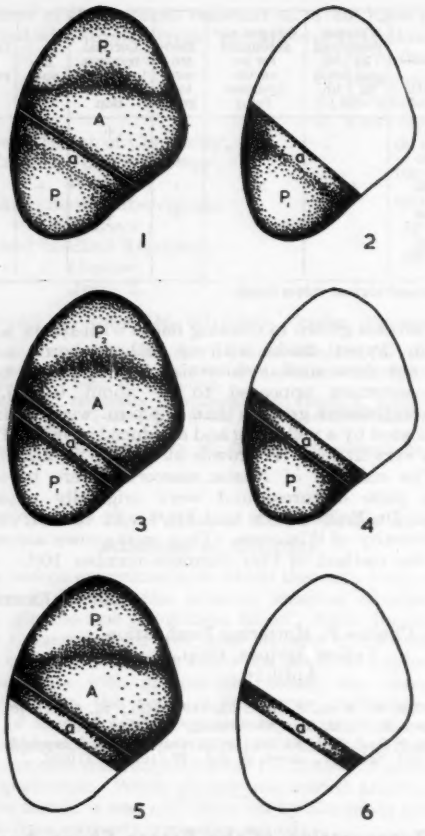
Regeneration of the Potato Shoot Apex

The apical meristem of the shoot in most species of plants is domed above the insertion of the leaf primordia, and its flanks slope symmetrically from the summit to the regions where differentiation is proceeding. When the distal cells in the apical meristem of ferns[1,2] or angiosperms[3,4] are punctured, regeneration of the flanks is promoted. From such experiments it has been concluded that physiological dominance within the apical growth field is an attribute of a small number of cells situated at the distal extremity of the apical meristem[5]. It is appropriate, therefore, to inquire as to the mechanism by which the form of the meristem is preserved. The persistence of such form is the earliest and most fundamental expression of morphogenesis in the shoot, the subsequent morphological developments being conditional on the continued orderly growth of the apical meristem.

As part of a larger series of experiments planned to shed light on this problem, a small panel of meristematic tissue which formed part of the apical flank just distal to P_1, the youngest emergent leaf primordium, that is, just above its axil, was isolated in various ways from either or both P_1 and the remainder of the apical meristem (*A* in Figs. 1–6). It was thereby hoped to isolate the panel *a* from possible hormonal and nutritional competition from P_1 and the apical meristem. From other experiments it was known that there is lateral and acropetal, apolar, transmission of a hormone-like stimulus



Figs. 1–6 illustrating diagrammatically the apex immediately after the operations. Numbers correspond with those of treatments 1–6 in the table, and the conditions it was hoped to establish in each treatment are indicated there

within the limits of the apical meristem, but coincidental with tissue differentiation the stimulus is transmitted in a strictly basipetal, polar, direction. The incisions were therefore made sufficiently deep to penetrate all the meristematic layers, but not so deep as to interfere with the nutrient supply in the subapical region. Such incisions preclude hormonal inhibition of growth in the panel *a*. Nutritional competition, and the effects of substances which diffuse without polarity from P_1 or the apical meristem, may be prevented by excising one or both of the competing regions.

Results of the six treatments are presented in the accompanying table. Regeneration of the panel *a* involves the formation of a small new apical meristem, the records being made when the first leaf became emergent on it. Casual leaf inception, unrelated to apical activity, was never observed. The results of treatments 3 and 4 are closely comparable to those of treatments 1 and 2 respectively, because, whereas the incision isolating *a* from *A* always gaped, that between *a* and P_1 became compressed and the cut surfaces regrafted. It has not yet been possible to introduce impermeable substances into the incision without damaging the panel.

In treatments 1, 3 and 5 twenty-one of sixty panels regenerated one or two leaves each. None continued to grow further, but remained in an inhibited but embryonic state on the stem flank. Excision of P_1 increased the number of panels on which leaves emerged, not directly, by facilitating leaf inception, but by promoting a more rapid growth of the panel along its proximal–distal axis.

In treatments 2, 4 and 6 nearly all the panels regenerated, and regeneration commenced before that in the other three treatments. P_1, when present, was able to to retard the growth of the panel temporarily, but was unable to inhibit it entirely.

On this evidence the regulation of growth on the flanks of the apical meristem is apparently dependent mainly on the activity of the apical meristem itself, that is, the apical meristem is a self-regulatory field of growth. Hormonal inhibition of growth appears to be of relatively little importance, nutritional competition being the factor limiting regeneration in these experiments. Leaf primordia exert a transitory and localized inhibitory action on the growth of the apical flank, which is indicated by a flattening of the apical surface just distal to the insertion of a leaf. Since inhibition of regeneration by P_1 is strongest before the maximum rate of growth of this leaf is reached, it may be suggested that nutritional competition is of a rather specialized type, confined perhaps to requirements for the growth of meristematic tissues.

Ball[9] has shown that when the apical meristem of *Lupinus* is divided into six sectors all may regenerate, and has concluded that this is the minimal area able to regenerate in this species. In the present experiments the isolated panel was equal in area to one-sixth of the apical meristem. There were four cells along the proximal–distal axis of the panel, and twelve to fifteen along the tangential axis.

Smaller panels, obtained by incising the panel *a* at right angles to the first incisions, have been caused to regenerate by excision of the remainder of the apical meristem. Regeneration occurred whether or

Regeneration of the isolated panel *a* during six days. 20 shoots were used in each treatment. In column 1, H and N refer to hormonal and nutritional competition respectively of the apical meristem *A* and P_1. + and − indicate whether or not such competition is occurring. Ra = regeneration of panel *a*, and L = the total number of leaf primordia on 20 panels of each treatment. The final column gives the average number of leaves on a panel after six days

Treatment		Day 2		Day 3		Day 4		Day 6		L/20
		Ra	L	Ra	L	Ra	L	Ra	L	
1	−HA +NA +HP$_1$ +NP$_1$	0	0	0	0	3	3	3	3	0·15
2	−HA −NA +HP$_1$ +NP$_1$	0	0	7	7	14	21	20	52	2·6
3	−HA +NA −HP$_1$ +NP$_1$	0	0	0	0	2	2	5	6	0·3
4	−HA −NA −HP$_1$ +NP$_1$	0	0	7	7	14	23	18	43	2·15
5	−HA +NA −HP$_1$ −NP$_1$	0	0	0	0	8	10	13	16	0·8
6	−HA −NA −HP$_1$ −NP$_1$	2	3	14	18	20	38	20	63	3·15

not a part of P_1 was left attached. The smallest pieces of apical tissue which regenerated had only twelve cells in the superficial layer, and were equivalent to not more than one-twentieth of the area of the apical meristem. The vascular system of such regenerated shoots was invariably solenostelic.

On two occasions out of 123 very small apical panels failed to regenerate as shoots, but underwent a limited amount of growth, developing as centric organs similar to those previously obtained by isolating a presumptive leaf position from the apical meristem[7].

The experimental evidence presented here indicates that very small groups of superficial cells of the apical meristem are able to regenerate a shoot, providing they are freed from the competition of other regions of the apical meristem for the supply of available nutrients from the subapical region, and that such competition between different regions of the apical meristem is one of the regulatory mechanisms by which the form of the apical meristem is preserved.

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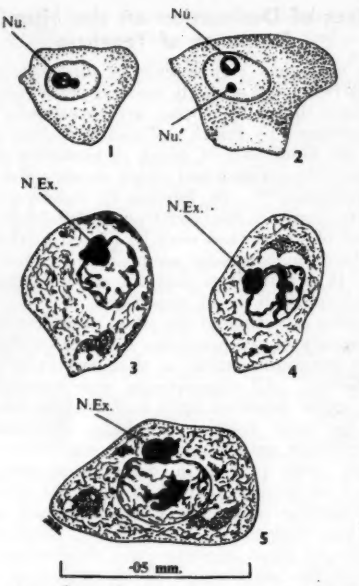
Extrusion of Nucleolar Material in the Female Germ-Cells of *Lumbricus terrestris* L.

So far as I am aware, the extrusion of nucleolar material into the cytoplasm has not been recorded for the female germ-cells of *Lumbricus* or any other earthworm. In this connexion, Harvey[1] remarked that in the nuclei of the "nearly ripe oocytes there may occur little droplets of material, similar in reactions to the plasmosome. They may be lying on the surface of this body, or may be entirely separate. Occasionally they are seen on the nuclear membrane, but never outside it. This may point to extrusion of nucleolar fragments, but only on a very small scale and never into the cytoplasm". Gatenby and Nath[2] observed that: "Neither Harvey nor the present writers have found any satisfactory evidence of nucleolar emission in *Lumbricus*".

My preparations of the ovaries of *Lumbricus*, fixed in Bouin's fluid and stained with Ehrlich's hæmatoxylin or iron-hæmatoxylin, show convincingly that extrusion of nucleolar material takes place. The nucleolus is stained a purplish colour with Ehrlich's hæmatoxylin. Often the nucleus contains two nucleoli, and in such cases the larger one contains one or more lightly stained droplets, while the smaller body appears to be homogeneous (Figs. 1 and 2); the latter seems to originate from the large nucleolar body (Fig. 1) and is ultimately extruded into the cytoplasm. After iron-hæmatoxylin, the nucleolus and nucleolar extrusion are uniformly black throughout.

The nucleolar material which is extruded into the cytoplasm takes the form of a large, spherical nucleolus-like body which seems to press against the nuclear membrane and gradually passes into the cytoplasm, where finally it breaks up into smaller particles. The process appears to take place repeatedly, as I have observed it in oocytes of different sizes. Figs. 3 and 4 show two stages in the emission of nucleolar material; in Fig. 3, a nucleolar extrusion has passed half-way through the nuclear membrane, while in Fig. 4, an extrusion in another oocyte lies almost wholly in the cytoplasm. In Fig. 5, a similar body is shown in the cytoplasm, and already shows signs of breaking up into smaller pieces.



Oocytes of *Lumbricus terrestris* from sections of ovary fixed in Bouin and stained with Ehrlich's hæmatoxylin (Figs. 1–2) or iron-hæmatoxylin (Figs. 3–5).
Nu., nucleolus; *Nu'.*, smaller nucleolus; *N.Ex.*, nucleolar extrusion

The presence of nucleolar extrusions in the female germ-cells of many animals has previously been described. Among annelids, the classical example of *Saccocirrus*, recorded by Gatenby[3], is well known. Unlike *Saccocirrus*, however, the extrusions of *Lumbricus* are large, spherical bodies resembling a nucleolus; in fact, in this animal the nucleolar extrusions more closely resemble those of *Libellula depressa* described by Hogben[4]. The presence of nucleolar extrusions indicates that the female germ-cells of *Lumbricus*, and probably those of other earthworms, are much more complex structures than supposed by previous workers such as Nath and his collaborators[2,5,6].

I wish to express my thanks to Prof. R. A. R. Gresson, for guidance and valuable help.

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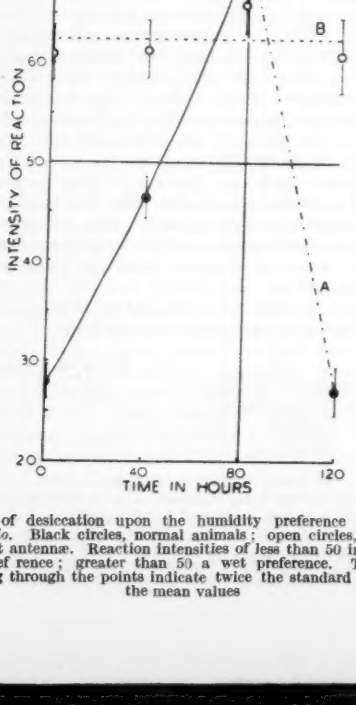
Effect of Desiccation on the Humidity Response of *Tenebrio*

The ecological significance of an experimentally demonstrated and strongly marked preference for low humidities shown by certain arthropods has recently been discussed by Smith[1]. *Tenebrio molitor* L. is one insect the behaviour of which in humidity gradients has been fully studied and which shows a well-defined dry preference[2–4]. In laboratory cultures of adult *Tenebrio*, however, we have frequently observed that, if a wad of wet cotton-wool be placed in the culture dish, the animals rapidly accumulate on the wool and drink. It is thus clear that the dry preference does not express itself in all conditions.

We have investigated the effect of desiccation upon the intensity of the humidity response of this insect, using a technique similar to that employed by Gunn and Pielou[2]. All experiments were carried out at 25° C. under artificial light and with a gradient of 93–44 per cent relative humidity. Animals from stock cultures maintained at the experimental temperature were placed in dishes containing damp cotton-wool for a period of 12 hr.; the intensity of their humidity preference was determined and they were then desiccated over calcium chloride. The intensity of their response was redetermined after 40 and 80 hr. At the end of this period the animals were returned to the dishes containing the damp cotton-wool and, after a period of 40 hr., their response was again assessed. The results obtained are shown in curve *A* of the accompanying graph, which is based upon seven independent experiments.

It will be seen that there is a change in the humidity preference as the desiccation proceeds. Once the animals are allowed renewed access to water, the original dry preference is shown. There is no significant difference between the reaction intensities of watered animals before and after the period of desiccation. This eliminates the possibility that starvation has contributed to the changing pattern of humidity behaviour, as has been found by Willis and Roth[5] in *Tribolium*.



Effect of desiccation upon the humidity preference of adult *Tenebrio*. Black circles, normal animals; open circles, animals without antennæ. Reaction intensities of less than 50 indicate a dry preference; greater than 50 a wet preference. The lines running through the points indicate twice the standard errors of the mean values

Gunn and Pielou were able to show that the receptors responsible for the initiation of the dry preference of *Tenebrio* lay in the antennæ. Over a short gradient of 100–94 per cent relative humidity they found no response to humidity by animals lacking antennæ. We have been able to confirm this observation. We find, however, that with the wide gradient of 93–44 per cent relative humidity a wet preference is exhibited. The intensity of this preference is but slightly affected by desiccation. Although the intensity of the final wet preference of normal desiccated animals is slightly greater than that of comparable animals without their antennæ, we are unwilling to conclude at the moment that any specific sense organs concerned with a wet preference lie on the antennæ. It is clear, however, that such sense organs must exist elsewhere on the body.

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[1] Smith, A., *Bull. Ent. Res.*, **42**, 585 (1951).
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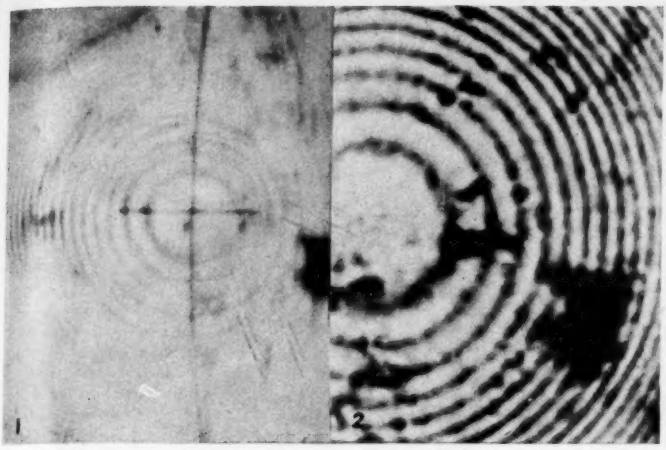
Evaluation of Small Radii of Curvature using the Light-Profile Microscope

The light-profile microscope described by Tolansky[1] is being applied in this laboratory to several fields, including the study of features of crystal growth[2], the measurement of the thickness of thin film[3] and evaluation of amplitudes of oscillation[4]. In this communication a brief description is given of a further application, whereby the radii of curvature of small spheres, droplets, cavities, etc., can be readily measured.

When the light profile passes over a curved surface, a curved profile line appears in the field of view, a spherical surface leading to a profile which approximates to part of an ellipse, the eccentricity of which is determined by the ratio of the magnifications in extension and in depth. From the curved profile and the known magnifications, the curvature of the surface can be evaluated. (Depending on the flatness of field of the particular objectives available, it may in individual cases be necessary to determine field curvature and correct for this—an easy matter.)

The reliability of the procedure has been tested by using it on a steel ball-bearing of radius 0·6 mm., for with such an object Newton's rings can readily be obtained to give a precise local value of curvature. Furthermore, a principal advantage of the light profile is the availability of high power. The steel ball was placed on a cover slip and examined with λ 5,461 at $\times$ 875 (4-mm. objective). Newton's rings are seen in Fig. 2. Fig. 1 shows the light profile at $\times$ 450 in extension. The optical arrangement suited to the light profile is not the best for interferometry,



hence Newton's rings can be seen only faintly, superposed on the profile. The radius of curvature calculated from the interference fringes is 0·596 mm. and from the profile 0·595 mm., the estimated error in the latter being some ± 1 per cent (that is, ± 0·005 mm.).

There is, then, complete confirmation of the reliability of the light-profile method, particularly for measuring curvature of small bodies or small cavities. Spherical cavities, such as those produced in micro-indentation by spheres or ball-ended diamonds, erosion pits, cavities produced by spark discharges on metals, etc., are but some of the features now under examination.

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Thermionic Constants of the Iron Group of Metals

In a recent communication[1], we gave an account of a new method of determining the thermionic constants of graphite, which is based on the determination of the saturation vapour pressure of the electron gas in equilibrium with the substance at different known temperatures, and application of the well-known thermodynamic relation of Clausius and Clapeyron. In the actual experiments, the saturation vapour pressure of the electron gas in a graphite chamber is determined by finding the rate of effusion of the gas into vacuum through a small hole in a thin wall of the chamber. The chamber is in the form of a thin-walled tube, and can be heated to any desired high temperature by sending a suitable heavy electric current through it. In order to eliminate the electrons emitted by the graphite surface adjoining the effusion hole, the surface is covered by a thin sheet of mica, with a small hole punctured in it; this comes just in front of a bigger one in the graphite wall and serves as the effective effusion hole.

This method of determining the thermionic constants, and in particular the coefficient A in Richardson's equation, has advantages over the other methods, since it is insensitive to the usual type of contamination of the emitting surface; and further, it does not require a knowledge of the effective area of the emitting surface or of the reflexion coefficient of the electrons at the surface.

The inner walls of the graphite chamber, as also the regions close to the effusion hole, can be coated suitably with other metals, and the method can thus be used for the determination of the thermionic constants of these metals also. We have determined in this manner the thermionic constants of chromium, iron, cobalt and nickel, depositing the metals both electrolytically and by evaporation from a tungsten wire coated previously with the metal, or carrying small rings of the metal. The results were found to be independent of the method used for the deposition of the metal and were reproducible.

The observations fit well with Richardson's equation:

$$i = AT^2 \exp(-\varphi/kT), \qquad (1)$$

in which A and φ are independent of temperature, and have the values given in the accompanying table.

Metal	φ (eV.)	A (amp. cm.$^{-2}$ deg.$^{-2}$)
Chromium	4·58	60
γ-Iron	4·31 ±0·02	60 ±2
Cobalt	4·41	60
Nickel	4·50	120 ±5
Note added in proof, October 8.		
Titanium	3·95	44
Vanadium	4·12	50
Manganese	3·83	34

As is well known, the observed fit of the experimental data with formula (1) with temperature-independent constants A and φ cannot be regarded as excluding a small linear variation of the actual work function with temperature, since such a variation will be equivalent to a temperature-independent change in A. Apart from the normal thermal expansion of the metal, which will lead to a small temperature variation of the work function, there is a further source of such variation in these metals. The d- and the s-energy bands of these metals overlap, the former being nearly full, and having a much larger density of energy-states than the latter. As a result, (1) the electronic specific heat in the condensed phase will be considerable, and (2) on change of temperature there will be a transference of electrons from one band to the other, and a consequent change in the work function[2]. Hence experimental data for the thermionic constants of the transition elements are of special interest.

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New Delhi. April 15.

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γ-Rays of Radium-D

A Cauchois type of curved crystal spectrometer[1] has been employed to study the γ-radiation from radium-D using a 100-mC. source.

The source was produced at the Radiochemical Centre, Amersham, by anode deposition on a dished platinum foil of area ¼ sq. in. The total weight of inactive deposit was 2·1 mgm. An aluminium foil of thickness 0·05 mm. was sealed over the source. The β-particles of radium-E were absorbed in a filter-paper screen of superficial mass 0·45 gm./cm.².

The γ-spectrum was recorded on Ilford *G* 5 nuclear plates coated to a thickness of 200 μ. The developed plates were scanned by microphotometer and the resulting observations were corrected for absorption before the photographic plate and for variation of the sensitivity of the photographic plate with wavelength. Exposures of 700 hr. were made, covering at full aperture the energy ranges 62–19 keV. and 50–16 keV. The well-known γ-ray was found at 265·96 ± 0·13 X.U. or 46·52 ± 0·02 keV., in good agreement with earlier observations[2] recalculated on the basis of recent values of the physical constants[3]. No other γ-ray was observed between the upper limit of observation at 62 keV. and the upper limit of the *L* X-ray spectrum of radium-E ($L\gamma_4$) at 16·2 keV. γ-Rays within this region have been reported by various authors[4,5], though inconclusive or negative results have been obtained by others[5].

The upper limits set by our observations to the intensities of the γ-rays reported by Tsien[4] relative to the intensity of the 46-keV. line are as follows:

Energy of γ-ray (keV.)	46·5	42·6	37	31	23·2	16·1
Relative intensity	1	≤0·015	≤0·015	≤0·015	≤0·025	≤0·06

A full account of the experimental technique and of other measurements will be published at a later date.

The mica crystal used in this work was kindly given by Prof. S. Tolansky. A further gift of mica crystals from Dr. J. M. Rayner is gratefully acknowledged. The work was sustained for two years by a grant from the Department of Scientific and Industrial Research to one of us (G. T. E.).

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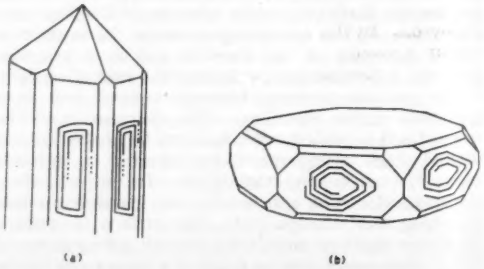
Growth Spirals and their Relation to Crystal Habit as Illustrated by Apatite

The observation of growth spirals, as predicted by the theory of Burton, Cabrera and Frank[1], on prism faces (10$\bar{1}$0) of apatite crystals, has been reported earlier[2]. We have now observed completely differently shaped growth spiral patterns on tabular colourless apatite crystals from Sulzbachtal (Austria), which have probably grown from solution. The accompanying photograph (Fig. 1) shows one of the observed patterns. The direction of the *c*-axis is vertical. The shape and orientation of the spiral are the same in all cases. The dominating system consists of two co-operating spirals, which dominate several other dislocations of equal and of different strengths. In the latter case the formation of residual steps is noticed. Interlacing occurs in one direction. The main growth-fronts have a step-height of 140 ± 20 A.

Fig. 1

By introducing a two-dimensional reference system with the apatite parameters $c : a = 0{\cdot}73 : 1$ as units, indices similar to the Miller indices for planes can be given to the growth fronts. These are, respectively, 01, 11, 10, 1$\bar{1}$, 0$\bar{1}$, $\bar{1}\bar{1}$, $\bar{1}$0 and $\bar{1}$1. Perpendicular to these directions we consequently have eight sharp minima for the growth velocity, and the following relations exist: $v_{10} > v_{01} = v_{0\bar{1}} > v_{\bar{1}\,\bar{1}} = v_{\bar{1}1} > v_{\bar{1}0} > v_{11} = v_{1\bar{1}}$. The subsequent polar diagram has only a line of symmetry perpendicular to the *c*-axis, which is consistent with the crystal class of apatite. The spirals are oriented in the same way on the six prism faces, proving the presence of a hexad symmetry axis.

When comparing the shape of the spirals described earlier and the shape of the present ones with respect to the habit of the crystals, a striking similarity will be noticed between the outline of the prism faces and the shape of the spiral growth fronts. This relation is shown schematically in Fig. 2, where (*a*) represents



(a) (b)

Fig. 2

a prismatic crystal (Jumilla) and (*b*) a tabular crystal (Sulzbachtal), with their respective growth patterns.

As one can scarcely imagine an influence of the edges of the prism faces upon the growth fronts and imposing their outline to them, one must rather accept the contrary, that is, that crystal habit results from the shape of the growth spirals. Agents changing the relative growth-rates of growth fronts would influence crystal habit in such a way that edges will be developed perpendicular to directions of minima for growth velocities on the close-packed faces.

These observations further support the idea that habit modification by foreign substances would proceed rather by selective adsorption along growth fronts than by adsorption on certain crystal planes.

I wish to thank Prof. W. Dekeyser for his kind interest, the C.N.B.C.P.M. for support, and the Mineralogy Department of Koninklijk Belgisch Instituut voor Natuurwetenschappen (Brussels) for the loan of specimens.

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July 18.

[1] Burton, Cabrera and Frank, *Phil. Trans. Roy. Soc.*, A, **243**, 299 (1951).
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Determination of the Pore-Size Distribution in Porous Metal Bodies

The pore-size distribution of a porous metal body can be defined in three ways, namely, those given by the expressions $\partial V/\partial r$, $\partial\alpha/\partial r$ and $\partial N/\partial r$, where r is the 'radius' of the pore and ∂V, $\partial\alpha$ and ∂N respectively represent volume, permeability and number of pores associated with the pore-size interval r to $(r + \partial r)$. $\partial V/\partial r$ may be determined by observing the capillary rise of a liquid in a narrow strip of the material. If h is the capillary rise, a simple equation relates h to r, and $\partial V/\partial h$ is readily determined by breaking the strip at h_1, h_2, h_3 . . . and weighing the pieces to ascertain the values of V corresponding to the sections $(h_1 - 0)$, $(h_2 - h_1)$, $(h_3 - h_2)$. . . .

If the perimeter of a section through a pore is P and the area of the section A, then equating forces acting on the surface of the liquid that has risen in the pore and neglecting the weight of the liquid above the meniscus, we may write:

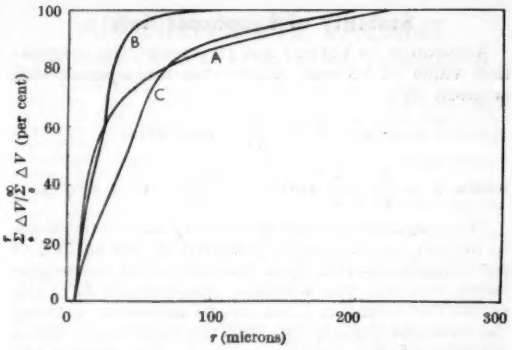
$$P\sigma\cos\beta = Ahdg,$$

where σ is the liquid – air interfacial tension and β is the angle of contact between the liquid of density d and the material from which the porous body is made. The value for A/P thus determined is equal to $r/2$ if the pores are circular in section; it is therefore implied in the sequel that the 'radius' of a pore (r) is that calculated as $2A/P$. This is in error inasmuch as the pores are not circular in section.

The smallest pore that can be determined by a capillary rise method has a 'radius' given by

$$r = \frac{2\sigma\cos\beta}{X},$$

where X is the atmospheric pressure. In order to extend the determination of the distribution of pore size to the very smallest pores, it is therefore necessary to use a liquid of very low surface tension to fill them.



(*A*) and (*B*), pores filled with water; (*C*), pores filled with acetanilide

The values of h corresponding to the values of r (5–250 μ) which commonly occur in metallic filter materials are inconveniently large if water is used as the pore-filling liquid and rises against the force of gravity.

Increasing g by means of a centrifuge enables a determination of the distribution of the pore-sizes from 7 to 250 μ (which contain more than 99 per cent of the total pore volume) to be made on a piece of porous stainless steel 10 cm. × 1 cm. × 0·3 cm. The accompanying graph shows three typical pore-size distribution curves of samples of porous stainless-steel filter materials. Curves *A* and *B* were determined by centrifuging the porous sample in the presence of a slight excess of water, which was thus distributed in the pores under the mutually opposing forces of surface tension and increased gravity. An addition of liquid oxygen by means of a specially designed funnel was made, to freeze the water in the pores while the centrifuge was still spinning. The specimen was then broken at the points h_1, h_2, h_3 . . . into previously weighed weighing bottles before the ice melted. After weighing, the water was removed from the broken pieces in an oven at 110° C. and the broken pieces reweighed to determine their water contents.

Organic compounds may also be used as pore-filling liquids. As an example of their use, the results plotted as curve *C* were determined with acetanilide. A small furnace was mounted in one of the centrifuge tubes, slip rings providing the means of carrying the heating current to it and the thermal E.M.F. from it to a pyrometer. Molten acetanilide (melting point 114° C.) was allowed to distribute itself through the pores of the metallic compact under the forces of its surface tension and the increased g due to centrifugal forces. On being allowed to cool, it solidified in position and its distribution through the metal could be determined in a manner similar to that used for the ice-filled porous metal.

A full account of this work is being prepared for publication elsewhere.

I wish to acknowledge the help of Mr. K. Simpson, who did part of the experimental work; and to thank Mr. D. A. Oliver, director of research to the B.S.A. Group of Companies, for his encouragement and support of this work.

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Stability of Lyophobic Sols

According to Verwey and Overbeek[1], the coagulation value of various electrolytes for aqueous sols is given by:

$$c = 8 \times 10^{-22} \cdot \frac{\gamma^4}{A^2 . v^1} \text{ mol./litre,} \qquad (1)$$

where $\gamma = \frac{e^z - 1}{e^z + 1}$, and $z = \frac{\varepsilon . v . \psi_0}{k . T}$, $A = \pi^2 . q^2 . \lambda$.

The coagulating power of electrolytes is thus shown to depend on the electric potential on the surface of the colloidal particle (ψ_0), the valency of the coagulating ion (v), the absolute temperature (T), the number of atoms in 1 c.c. of the substance forming the colloidal particle (q), and the constant λ which appears in the equation $V = -\lambda/r^6$, giving the attractive potential due to the Van der Waals forces; ε is the electronic charge and k the Boltzmann constant. Although equation (1) is based on a rather crude physical model, namely, the interaction of plane electrical double layers, and although it has a limited range of applicability, being valid only if $d.\varkappa \gg 1$ ($1/\varkappa$ is the thickness of the ionic atmosphere and d is the mutual distance of the interacting colloidal particles), that is, for weak interaction of colloidal particles only, it nevertheless leads to a quantitative formulation of the Schultze–Hardy rule.

Wo. Ostwald[2] formulated a theory of coagulation of lyophobic sols which does not consider the mutual interaction of individual colloidal particles, but concentrates on the physical state of the dispersing medium, namely, the electrolytic solution of the coagulating ions. According to this theory, based on a careful study of experimental results, the stability of a given sol is influenced only by the 'activity coefficient' of the coagulating electrolyte. Independently of the type of electrolyte, the coagulation takes place at an approximately constant value of the activity coefficient of the coagulating ('dominant') ion. This theory, which seems to be just the opposite of the Verwey–Overbeek theory, may be formulated as follows:

$$f_c \approx \text{constant,} \qquad (2)$$

where f_c is the activity coefficient of the 'dominant' ion at which the coagulation takes place.

It may be of interest to direct attention to the close connexion existing between Ostwald's rule $f_c \approx$ constant, and the results of the simplified Verwey–Overbeek theory, which according to my knowledge has not been noticed in the literature. In fact, it may be shown that Ostwald's rule follows directly from the Verwey–Overbeek theory.

For symmetrical (1–1, 2–2, etc.) electrolytes the Debye–Hückel theory gives the activity coefficient of an ionic species in water at 25° C. as

$$-\log f_c = 0{\cdot}509 \sqrt{c . v^6}. \qquad (3)$$

Substitution of equation (1) in equation (3) gives

$$-\log f_c = 1{\cdot}44 \ \gamma^2 / A . 10^{11}. \qquad (4)$$

Since γ tends to unity even at moderate values of z, and A is a constant, equation (4) may be written as

$$-\log f_c \approx \text{constant,} \qquad (5)$$

which is another form of the equation (2). Thus it is shown that, at least for symmetrical electrolytes, Ostwald's rule follows from Verwey–Overbeek's theory. The numerical value of the constant depends on the choice of the value for A. Unfortunately, Verwey–Overbeek's theory cannot give a value for A without taking into account experimental results concerning the coagulation values of electrolytes.

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Inactivation of DDT by Soils

We have read with interest the recent communication in *Nature* from H. Maes[1]. His report of the work of I. Vincke, who has observed a rapid loss of insecticidal power of DDT on the walls of certain African houses in the Belgian Congo, provides further evidence for the sorption of DDT on lateritic soils described by us in 1951 [2]. It is also useful to find described a method for preventing this loss of efficiency; but we believe that the connexion between ability of soils to dehydrochlorinate DDT at elevated temperatures and loss of biological effectiveness is misinterpreted by Maes, and that the effect of spraying walls with phosphates is not due to inhibition of decomposition of DDT.

We have shown quite clearly that loss of effectiveness of surface deposits of DDT from wettable powders on certain soils is due to sorption of the DDT, and the presence of the undecomposed insecticide inside the soil structure can be demonstrated both colorimetrically and by recovery of crystalline DDT[3]. In addition, other insecticides, which are not susceptible to dehydrochlorination, disappear from the surface of soils in exactly the same way as DDT at rates which are approximately proportional to their vapour pressures. Possibly the sorbed DDT may be decomposed afterwards, particularly under dry conditions[3]; but the reaction is very slow at atmospheric temperatures compared with the sorption process and cannot account for the rapid loss of killing power against mosquitoes. However, as Downs *et al.*[4] have shown, there is a correlation between ability to dehydrochlorinate DDT in the Fleck and Haller method and the rate of loss of effectiveness on a wide range of soils, and therefore "the reaction of catalytic decomposition at 130° C. affords a rapid method for foretelling the capacity of a soil for inactivating DDT".

We would suggest the following possible reasons for the beneficial effect of pre-spraying mud walls with phosphate solutions. The correlation found by Downs *et al.* between the iron oxide contents of soils and the life of DDT residues on these soils would suggest that it is the iron oxide which provides the active sorbing surface. The phosphate ions may react with this surface to reduce its activity. Also, reaction with the ferric ions in the soil will produce gelatinous complex iron phosphates which may actually block the fine capillaries of the mud and retard diffusion of the insecticide vapours.

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Aug. 28.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, November 3

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. S. F. Smith: "Strain Measurements by Electronic Methods".

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. J. Baer: "Some Aspects of Adaptation to Parasitism in Animals", 1.* (Further Lectures on November 4 and 6.)

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. Alan St. H. Brock: "The Art and Craft of Firework Making".

UNIVERSITY OF LONDON (at Wye College, Wye, Ashford, Kent), at 8.15 p.m.—Prof. F. W. Went: "Plant Growth-regulating Substances".*

Tuesday, November 4

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. W. B. Emery: "Royal Tombs of the Nubian A-Group".*

INSTITUTION OF MECHANICAL ENGINEERS, AUTOMOBILE DIVISION (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. Charles A. Chayne: "Automatic Transmissions" (James Clayton Lecture).

PHYSICAL SOCIETY, ACOUSTICS GROUP (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Mr. R. S. Dadson and Mr. L. J. Wheeler: Papers on "The Threshold of Hearing".

Wednesday, November 5

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. J. H. Smith: "Social Aspects of Industrial Change".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

UNIVERSITY OF LONDON (in the Senate House, University of London, Malet Street, London, W.C.1), at 6 p.m.—Prof. F. W. Went: "The Effects of Environment on Growth and Development of Plants".* (Further Lecture on November 6.)

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. A. D. Booth: "The Specification and Design of Standardized Units for Electronic Computers".

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, BIOLOGICAL METHODS GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Papers on "The Bioassay of Vitamins with Special Reference to Microbiological Methods".

Thursday, November 6

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. R. B. Freeman: "The Biology of Bubonic Plague".*

PHYSICAL SOCIETY, OPTICAL GROUP (in the Lecture Hall, National Physical Laboratory, Teddington), at 2.30 p.m.—Scientific Papers.

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Dr. A. S. Parkes, F.R.S., and Audrey U. Smith: "Regeneration of Rat Ovarian Tissue Grafted after Exposure to Low Temperatures"; Mr. J. S. Perry: "The Reproduction of the African Elephant, *Loxodonta africana*".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Core, London, S.W.7), at 5.30 p.m.—Films for Geography Teachers.

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (at the Engineering Centre, Sauchiehall Street, Glasgow), at 7 p.m.—Mr. G. D. Clifford: "The Development of the Radio and Electronics Industry in India".

ROYAL INSTITUTE OF CHEMISTRY, LONDON AND SOUTH-EASTERN COUNTIES SECTION (joint meeting with the WEST HAM MUNICIPAL COLLEGE CHEMICAL SOCIETY, at West Ham Municipal College, Romford Road, London, E.15), at 7 p.m.—Dr. C. C. Hall: "The Fischer–Tropsch Synthesis".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Sir Robert Robinson, O.M., F.R.S.: Willstätter Memorial Lecture.

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Department of Psychology, University College, Gower Street, London, W.C.1), at 8.15 p.m.—Dr. J. C. Flugel: "The Psychology of Humour—Theory and Experiment".

Friday, November 7

ROYAL SOCIETY OF MEDICINE, OTOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 10.30 a.m.—Air Vice-Marshal E. D. D. Dickson: "Some Effects of Intense Sound and Ultra-Sound on the Ear" (Presidential Address).

SOCIETY OF DYERS AND COLOURISTS, LONDON SECTION (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. J. A. Radley: "Fluorescent Effects".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. D. P. Riley: "The Chemistry of an Egg".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (with experience of anthropological field work and, preferably, some qualification in psychology) IN THE DEPARTMENT OF SOCIAL ANTHROPOLOGY, to undertake tutorial duties and research in modern urban society—The Secretary, The University, Edinburgh (November 8).

ASSISTANT (Grade B) IN PHYSICS—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (November 8).

LECTURER to teach ELECTRICAL ENGINEERING subjects to ordinary and H.N.C. standards—The Principal, School of Electronics, Malvern, Worcs (November 8).

RESEARCH FELLOW IN SOCIAL PSYCHOLOGY—The Secretary, The University, Aberdeen (November 8).

SCIENTIFIC OFFICER (first- or second-class honours degree in engineering or physics essential) to work on problems connected with the fundamental aspects of machinery for plant pest and disease control—The Secretary, National Institute of Agricultural Engineering, Wrest Park, Silsoe, Beds (November 8).

SCIENTIFIC TECHNICAL OFFICERS, Grade I (preferably with Intermediate B.Sc., or equivalent, or National Certificates in appropriate subjects with previous experience in physics, operational production studies, instrument work, or mechanical and electrical engineering) at the Central Research Establishment, Isleworth—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/551 (November 15).

SUPERVISING GEOPHYSICISTS in the Bureau of Mineral Resources, Geology and Geophysics, Melbourne, to supervise and inspect all field operations in connexion with geophysical prospecting for mineral deposits, primarily coal, petroleum, natural gas and water—The Senior Representative, Division of Industrial Development, c/o Deputy High Commissioner, Australia House, Strand, London, W.C.2 (November 15).

LECTURER IN CHEMISTRY for the teaching of physical and inorganic chemistry—The Principal, Wigan and District Mining and Technical College, Wigan (November 17).

PRINCIPAL-DESIGNATE OF THE ROYAL TECHNICAL COLLEGE, Nairobi—The Secretary, Advisory Committee on Colonial Colleges of Arts, Science and Technology, 15 Victoria Street, London, S.W.1 (November 17).

SCIENTIST, Grade II (with a first- or second-class honours degree, or equivalent, in physics, engineering, mathematics or statistics, and at least three years postgraduate experience in laboratory or operational research) in the Field Investigation Group of the Directorate of Scientific Control—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/552 (November 17).

ASSISTANT MASTERS (with a university degree, or equivalent qualification, in Mathematics, Physics, Mechanical or Electrical Engineering) IN H.M. DOCKYARD TECHNICAL COLLEGES—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4168–52 (November 27).

PROFESSOR OF PHILOSOPHY at the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (November 30).

CHIEF SCIENTIFIC OFFICER in the Fisheries Research Unit attached to the Department of Biology, University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (December 1).

ORGANIC CHEMIST (with honours degree or equivalent, and considerable experience in industrial plastics) for research work on conveyor belting at the Central Research Establishment, Isleworth—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/556 (December 1).

ASSISTANT LECTURER IN PHYSICS at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (December 6).

PHYSICISTS or ELECTRICAL ENGINEERS at the Royal Aircraft Establishment, Farnborough: (Ref. A.281/52A) in charge of small team developing electronic equipment for guided missiles, experience in radar and communications techniques and circuit design essential; (Ref. A.282/52A) for design and development in physics and engineering fields of guided weapons control—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (December 12).

LECTURERS or SENIOR LECTURERS IN PHYSICS (two appointments may be at the grade of Reader) at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Sydney, January 12).

BOTANIST (with good honours degree in botany) for training in arboricides and herbicides research and subsequent work in East Africa, mainly on lay-out and detailed observation of experiments in application of chemicals to bush and forest—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

DEPUTY HEAD OF THE DEPARTMENT OF AIRCRAFT PRODUCTION—The Registrar, College of Aeronautics, Bletchley, Bucks.

ENTOMOLOGIST in the Department of Agriculture, Trinidad, for duties relating to the investigation of plant damage by insects and other animals and formulation and application of control measures—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CSC.63/38/01.

EXPERIMENTAL OFFICERS (with a pass degree in geology, mining, engineering or physics) for field work in Uganda—The London Director, Uganda Development Corporation, Ltd., 101 Grand Buildings, Trafalgar Square, London, W.C.2.

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments, the posts divided between the following main groups and subjects—mathematical and physical sciences, chemistry and metallurgy, biological sciences, engineering

subjects, and miscellaneous (including, for example, geology, library and technical information services)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.94–95/52.

Head of the Chemistry Department (Grade III), and a Head of the Physics Department (Grade II), Brighton Technical College—The Education Officer, 54 Old Steine, Brighton 1.

Lecturer in Civil Engineering—The Registrar, The University, Nottingham.

Lecturer (good honours degree essential) in Physical Chemistry—The Registrar, College of Technology, Bristol 1.

Lecturer (Grade B) in the Department of Mathematics—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

Research Assistant (with a University degree) to aid and initiate researches in the study of noise from aircraft and jets—The Secretary and Registrar, The University, Southampton.

Scientific Officers at Ministry of Supply research establishments in South-East England: (Ref. A.279/52A) Experimental Physicists (near Southend) with interest in light engineering or metallurgy; (Ref. A.280/52A) Theoretical Physicists or Applied Mathematicians (near Sevenoaks) (experience in astrophysics useful for one post)—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

Technical Assistant in the Fuel Section of the Plant Engineering Division, for work initially largely in connexion with the utilization, instrumentation and design of furnaces, and with operational studies involving the heating and cooling of steel ingots—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Fuel'.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Proceedings of the Royal Society of Edinburgh, Section B (Biology). Vol. 64, Part 4, No. 19: Quantitative Evolution, 21 Some Correlations in the Present Results of Production Rates. By Prof. James Small. Pp. 367–383. 3*s*. Vol. 64, Part 4, No. 20: The Rate of Growth of *Venerupis pullastra* (Montagu) at Millport, Scotland. By Dr. D. B. Quayle. Pp. 384–406. 4*s*. Vol. 64, Part 4, No. 21: Estimation of Fertile and Infertile Marriages and Size of Family. By C. Margaret Burns. Pp. 407–425. 3*s*. Vol. 64, Part 4, No. 22: A Preliminary Report on the Echiuridæ and Sipunculidæ of Zanzibar. By Dr. A. C. Stephen and J. D. Robertson. Pp. 426–444. 3*s*. 6*d*. Vol. 64, Part 4, No. 23: Sexual Maturity in Brown Leghorns; the Interactions of Genotype and Environment. By Robert Osborne. Pp. 445–455. 2*s*. Vol. 64, Part 4, No. 24: On the Sampling Variance of Heritability Estimates derived from Variance Analyses. By Robert O. borne and W. S. B. Paterson. Pp. 456–461. 1*s*. Vol. 64, Part 4, No. 25: Observations on the Birthcoats and Skins of several Breeds and Crosses of British Sheep. By A. S. Fraser and M. K. O. Hamada. Pp. 462–477. 3*s*. (Edinburgh and London: Oliver and Boyd Ltd., 1952.) [27

Wax Chemistry and Technology. By Dr. L. Ivanovszky. Pp. ii+44. (Bridgend, Glam.: The Author, 68 Park Street, 1952.) [37

Colonial Development Corporation. Annual Report and Statement of Accounts for the Year ended 31st December 1951. (Cmd. 167.) Pp. viii+74. (London: H.M. Stationery Office, 1952.) 3*s*. net. [77

Colonial Development and Welfare Acts. Return of Schemes made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies, with the concurrence of the Treasury, in the period from 1st April 1951 to 31st March 1952. (Cmd. 211.) Pp. 44. (London: H.M. Stationery Office, 1952.) 1*s*. 6*d*. net. [97

British Welding Research Association. Seventh Annual Report, 1951–52. Pp. 32. (London: British Welding Research Association, 1952.) [177

Reporting Research in Education. By Stephen Wiseman. (Publications of the University of Manchester School of Education, No. 2.) Pp. vii+24. (Manchester: Manchester University Press, 1952.) 3*s*. 6*d*. net. [177

Medical Research Council. Memorandum No. 28: Employment Problems of Disabled Youth in Glasgow. By Dr. T. Ferguson, Dr. A. N. McPhail and Margaret I. McVean. Pp. vi+66. (London: H.M. Stationery Office, 1952.) 3*s*. net. [177

Ministry of Agriculture and Fisheries. Fishery Investigations, Series 2, Vol. 18, No. 1: Some Reactions of Pelagic Fish to Light as recorded by Echo-Sounding. By I. D. Richardson. Pp. 20. (London: H.M. Stationery Office, 1952.) 4*s*. net. [177

Ministry of Agriculture and Fisheries. Bulletin No. 148: Incubation and Hatchery Practice. By Dr. W. M. Allcroft. Pp. iv+62+8 plates. (London: H.M. Stationery Office, 1952.) 3*s*. net. [177

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 891, Vol. 245: The de Haas–van Alphen Effect. By D. Shoenberg. Pp. 57. (London: Cambridge University Press, 1952.) 13*s*. [177

Science Museum. Sailing Ships, their History and Development, as illustrated by the Collection of Ship-Models in the Science Museum. By the late G. S. Laird Clowes. Part 2: Catalogue of Exhibits, with Descriptive Notes. Fourth edition, revised and expanded by E. W. White. Pp. 124+28 plates. (London: H.M. Stationery Office, 1952.) 6*s*. net. [177

The Practice of Arable Crop Experimentation. By P. N. Harvey. Pp. vii+79. (Norwich: Norfolk Agricultural Station, Sprowston, 1952.) 6*s*. [177

Empire Cotton Growing Corporation. Annual Report for the Year ending 31st March 1952. Pp. ii+20. (London: Empire Cotton Growing Corporation, 1952.) [177

University of Reading: National Institute for Research in Dairying. Report, 1951. Pp. 126. (Shinfield: National Institute for Research in Dairying, 1952.) 3*s*. [177

Other Countries

Pubblicazioni della Università degli Studi di Firenze: Facoltà di Scienze Matematiche, Fisiche e Naturali. Fascicolo No. 67: Osservazioni e Memorie dell' Osservatorio Astrofisico di Arcetri. Pp. vii+142. (Firenze: Università degli Studi, 1952.) [37

Institut International de Physique Solvay. Neuvième Conseil de Physique tenu à l'Université Libre de Bruxelles du 25 au 29 septembre 1951. L'Etat solide: Rapports et discussions. Pp. 577. (Bruxelles: R. Stoops, 1952.) 650 francs. [167

Transvaal Museum. Report for the Year ending 31st March 1952. Pp. 40. (Pretoria: Transvaal Museum, 1952.) [177

Fieldiana. Geology, Vol. 10, No. 13: A Classification of the Conularida. By G. Winston Sinclair. Pp. 135–146. 20 cents. Geology, Vol. 11, No. 6: Early Devonian Fishes from Utah, Part 1, Osteostraci. By Robert H. Denison. Pp. 263–288. 50 cents. Zoology, Vol. 34, No. 1: References to the Tuatara in the Stephen Island Letter Book. By Karl P. Schmidt. Pp. 10. 20 cents. Zoology, Vol. 34, No. 2: A New Leptodactylid Frog from Chile. By Karl P. Schmidt. Pp. 11–16. 10 cents. Zoology, Vol. 34, No. 3: Notes on Birds from the Marcapata Valley, Cuzco, Peru. By Melvin A. Traylor, Jr. Pp. 17–24. 10 cents. (Chicago: Chicago Natural History Museum, 1952.) [177

University of Illinois Engineering Experiment Station. Bulletin Series No. 398: A Critical Review of the Criteria for Notch-Sensitivity in Fatigue of Metals. By C. S. Yen and T. J. Dolan. Pp. 55. 50 cents. Bulletin Series No. 399: A Study of Combined Bending and Axial Load in Reinforced Concrete Members. By Eivind Hognestad. Pp. 128. 1 dollar. Circular Series No. 63: An Economic Study of Fuels in Manufacturing. By Walter H. Voskuil. Pp. 28. 40 cents. Circular Series No. 64: What do we Know about Diagonal Tension and Web Reinforcement in Concrete?; a Historical Study. By Eivind Hognestad. Pp. 47. 50 cents. Reprint Series No. 48: Progress Reports of Investigation of Railroad Rails, Joint Bars and Rail Webs. By R. E. Cramer and R. S. Jensen. Pp. 47. 25 cents. (Urbana, Ill.: University of Illinois, 1952.) [177

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Bureau Climatologique, Communication No. 4: Bulletin climatologique annuel du Congo Belge et du Ruanda-Urundi, année 1950. Pp. 103. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1952.) [177

Canada: Department of Mines and Technical Surveys, Mines Branch. Memorandum Series No. 120: Preliminary Report on Coated Lightweight Concrete Aggregate from Canadian Clays and Shales, Part 2, Manitoba and Saskatchewan. By J. G. Maitland. Pp. iv+50. (Ottawa: King's Printer, 1952.) [177

Commissariat à l'Énergie atomique. Répertoire analytique à l'usage des physiciens nucléaires, 1. (Publications parues du 1er Janvier 1950 au 30 Juin 1951.) Établi par le Service de Physique Nucléaire avec le concours technique du Service de Documentation. (Rapport C.E.A. No. 120.) Pp. xvii+367. (Fontenay-aux-Roses: Laboratoires du Fort de Châtillon, n.d.) [177

Research Proceedings of Mellon Institute, 1951-1952 (Annual Report Series No. 39): The Annual Report of the President, Edward R. Weidlein, to the Board of Trustees of the Institution, for the Fiscal Year ended February 29, 1952. Pp. vi+50. (Pittsburgh, Pa.: Mellon Institute, 1952.) [177

South African Institute for Medical Research. Annual Report for the Year 1951. Pp. 100. (Johannesburg: South African Institute for Medical Research, 1952.) [177

Commonwealth Scientific and Industrial Research Organization. Bulletin No. 264: A Pedological Study of the Soils occurring at Coomealla, New South Wales. By K. H. Northcote. Pp. 128+7 plates. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1951.) [177

Southern Rhodesia. Report of the Director, Geological Survey, for the Year 1951. Pp. 8. (Salisbury: Government Printer, 1952.) [177

Commonwealth of Australia: Department of External Affairs. Australian National Antarctic Research Expedition. Interim Reports, 2: Hourly Measurements of Ionospheric Characteristics, Macquarie Island, 1950. By D. S. Cohen. Edited by P. G. Law. Pp. iv+81. (Melbourne: Antarctic Division, Department of External Affairs, 1952.) [177

Administration Report of the Government Museum, Madras, the Government Museum, Pudukkottai, and the Connemara Public Library (Exchange Section), Madras, for 1950–51. Pp. iii+51. (Madras: Government Press, 1952.) [177

The Useful and Ornamental Plants in Trinidad and Tobago. Revised fourth edition by R. O. Williams and R. O. Williams, Jr. Original edition by W. G. Freeman and R. O. Williams. Pp. 335. (Port of Spain: Department of Agriculture, 1951.) 2 dollars. [177

East African Meteorological Department. Annual Report, 1951. Pp. iii+20. (Nairobi: East African Meteorological Department, 1952.) [177

Merentutkimuslaitoksen Julkaisu (Havsforskningsinstitutets Skrift). No. 146: Vedenkorkeusarvoja 1944. Av Ilmo Hela. Pp. 46. No. 147: Observations on Currents and Winds made on board Finnish Light-Ships during the Years 1948 and 1949. By Eugenie Lisitzin. Pp. 41. No. 148: Vedenkorkeusarvoja 1945 ja 1946. Av Ilmo Hela. Pp. 78. No. 149: Studier över Strömmingen i ostra Kvarken. Av Gunnar Ehnholm. Pp. 94+xxi. No. 150: Regular Observations of Temperature and Salinity in the Seas around Finland, July 1946–June 1950. By Gunnar Granqvist. Pp. 35. No. 151: Das Kohlensäure Gleichgewichtsystem im Meerwasser; kritische Durchsicht und Neuberechnungen der Konstitutionen. Von Kurt Buch. Pp. 18. No. 152: Harmonic Analysis of Temperature and Salinity in the Sea off Finland and Changes in Salinity. By Gunnar Granqvist. Pp. 29. (Helsinki: Merentutkimuslaitos, 1951–1952.) [177

Canada: Department of Transport. Climate of the Canadian Arctic Archipelago. By R. W. Rae. Pp. vi+90. (Toronto: Department of Transport, 1951.) 35 cents. [217

Reports of the Biochemical Research Foundation of the Franklin Institute. Vol. 11, 1950–1951. With an Index to BRF Publications Nos. 1 to 260 and BRF Notes Nov. 1938 to Dec. 1951, bound in Reports from the Biochemical Research Foundation, Vols. 1 to 11. 1930–1951. Pp. v+Publications 243–260+91+26. (Newark, Del.: Biochemical Research Foundation, 1952.) [217